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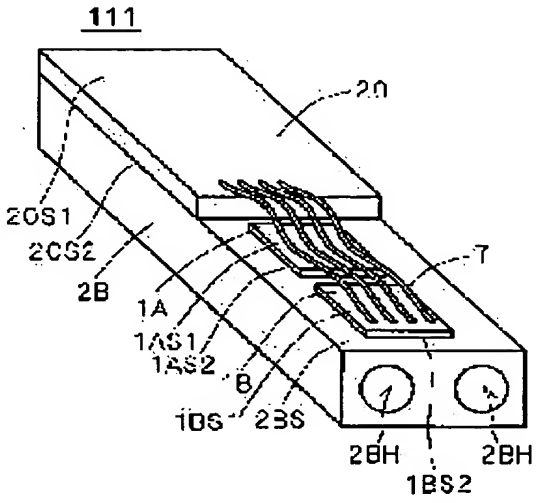
(54) POWER MODULE

(57)Abstract:
PROBLEM TO BE SOLVED: To reduce in size a power module and to improve cooling and reliability.
SOLUTION: In the power module 111, free wheeling diodes 1A and IGBT1B and a DC current filtering capacitor 20 are disposed in series on the surface 2BS of a conductive heat sink 2B having through holes 2BH. Then, rear surface electrodes of the diodes 1a, IGBT1B and the capacitor 20 are, for example, adhered onto the heat sink 2B with solder, and the diodes 1A and IGBT1B and the capacitor 20 are electrically connected to the sink 2B. Meanwhile, the front surface electrodes of the diode 1A and IGBT1B and the capacitor 20 are connected with wires 7. A refrigerant flows in the holes 2BH of the sink 2B.



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The power module characterized by having a heat sink, the 1st power semiconductor device soon arranged on the aforementioned heat sink, and the capacitor soon arranged on the aforementioned heat sink.
[Claim 2] It is the power module with which it is a power module according to claim 1, and the aforementioned heat sink has two or more front faces, and the 1st power semiconductor device of the above and the aforementioned capacitor are characterized by being arranged on the aforementioned front face where the aforementioned heat sinks differ.
[Claim 3] It is the power module characterized by being a power module according to claim 1 or 2, and the aforementioned heat sink having the passage of a refrigerant.
[Claim 4] It is the power module which is a power module according to claim 1 to 3, and is characterized by for the aforementioned heat sink having had conductivity and the electrode of the 1st power semiconductor device of the above and the electrode of the aforementioned capacitor having pasted it up soon with the aforementioned heat sink.
[Claim 5] The power module which is a power module according to claim 4, and is characterized by having further the insulating substrate arranged on the aforementioned heat sink, and the 2nd power semiconductor device arranged on the aforementioned heat sink through the aforementioned insulating substrate.
[Claim 6] The power module characterized by having the 2nd power semiconductor device arranged soon on a power module according to claim 4, other heat sinks, and a heat sink besides the above.
[Claim 7] It is the power module which it is a power module according to claim 6, and the heat sink besides the above had conductivity, and the electrode of the 2nd power semiconductor device of the above has pasted it up on the heat sink besides the above soon, and is characterized by equipping the aforementioned power module with the insulating member which insulates a heat sink besides the above from the aforementioned electrode of the aforementioned heat sink and the aforementioned capacitor further.
[Claim 8] The power module which is a power module according to claim 7, and is characterized by having further the conductive member arranged on the aforementioned insulating member, and the flexible wiring which connects electrically between the 1st power semiconductor device of the above, and the 2nd power semiconductor device of the above while connecting with the aforementioned conductive member.
[Claim 9] The power module characterized by having the 1st power semiconductor device arranged soon on the electrode of a capacitor and the aforementioned capacitor.
[Claim 10] It is the power module characterized by being a power module according to claim 9, and the aforementioned electrode of the aforementioned capacitor having the passage of a refrigerant.
[Claim 11] The power module which is a power module according to claim 9, and is characterized by having further the insulating substrate arranged on the aforementioned electrode of the aforementioned capacitor, and the 2nd power semiconductor device arranged on the aforementioned electrode of the aforementioned capacitor through the aforementioned insulating

substrate.
[Claim 12] It is the power module characterized by being a claim 5 or a power module given in either 8 or 11, and the 2nd power semiconductor device of the above accomplishing the upper arm of the aforementioned power converter by connecting electrically the 1st power semiconductor device of the above, and the 2nd power semiconductor device of the above, and the 1st power semiconductor device of the above accomplishing the lower arm of a power converter.
[Claim 13] The plurality of the arm of the aforementioned power converter which is a power module according to claim 12, and contains an above top arm and the bottom arm of the above, The 2nd electrode which supplies the 2nd voltage to each 2nd power semiconductor device of the above of the 1st electrode which supplies the 1st voltage to each 1st power semiconductor device of the above of each bottom arm of the above, and each above top arm is included. It is the power module which is further equipped with the coaxial line projected and prepared from the arrangement side of the 1st power semiconductor device of the above, or the 2nd power semiconductor device of the above, and is characterized by for two or more aforementioned arms enclosing the aforementioned coaxial line, and arranging them by abbreviation regular intervals on a concentric circle.
[Claim 14] It is the power module which is equipped with the case characterized by providing the following, and is characterized by forming the space of the 1 continuation which two or more aforementioned heat sinks open a crevice mutually into the aforementioned space of the aforementioned case, are arranged, and consists of the aforementioned crevice and the aforementioned passage in the aforementioned space of the aforementioned case. Two or more heat sinks with which each has the passage of a refrigerant Two or more power semiconductor devices by which each was carried on the aforementioned heat sink Space which can contain two or more aforementioned heat sinks
[Claim 15] The power module which is a power module according to claim 14, and is characterized by pouring an insulating refrigerant in the aforementioned passage of the aforementioned heat sink.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates mainly to the technology which raises the cooling performance of a power module about a power module.
[0002]
[Description of the Prior Art] The 1st conventional typical external view of power module 101P is shown in drawing 34 . In power module 101P, copper base board 9P are arranged through heat-conduction grease (not shown) on radiation-fin or heat sink 2P, and insulating-substrate 5P are arranged on base board 9P. Furthermore, freewheeling-diode (it is also only hereafter called diode) 1AP and insulated-gate mold bipolar transistor (referred to also as IGBT below Insulated Gate Bipolar Transistor;) 1BP are arranged on insulating-substrate 5P.
[0003] In conventional power module 101P, copper foil 6P are formed in both the principal planes of insulating-substrate 5P, and copper foil 6P and base board 9P are soldered, and diode 1AP and IGBT1BP are soldered on copper foil 6P. Furthermore, electrode 3P are prepared through insulating-layer 4P on radiation-fin 2P. And predetermined electric connection is made by wire 7P. In addition, the composition containing radiation-fin 2P, diode 1AP, IGBT1BP, etc. is stored in the case (not shown).
[0004] A bus bar or wiring 91P are connected to electrode 3P, and bus bar 91P are pulled out besides the above-mentioned case. The current transformer for current detection or current transformer 92P are attached out of the case bus bar 91P. moreover, the object for direct-current smooth [of a cylindrical shape] -- capacitor 8P are prepared separately from radiation-fin 2P grade out of the case (illustration-ization of the topology is omitted)
[0005] The 2nd conventional typical external view of power module 102P is shown in drawing 35 . Power module 102P do not have above-mentioned base board 9P, but insulating-substrate 5P are arranged on radiation-fin 2P through heat-conduction grease. The structure of others of power module 102P is the same as that of above-mentioned power module 101P.
[0006] The 3rd conventional typical external view of power module 103P is shown in drawing 36 . Power module 103P are the so-called power converter. In power module 103P, all diode 1APs and IGBT1BP(s) are arranged on insulating-substrate 5P. In addition, heat sink 2B[of power module 103P] P has breakthrough 2BHP, and a refrigerant is poured by this breakthrough 2BHP. The structure of others of power module 103P is the same as that of above-mentioned power module 101P fundamentally.
[0007]
[Problem(s) to be Solved by the Invention] The conventional power modules 101P-103P have the following troubles. First, there is a trouble of a low in the reliability over the temperature at the time of operation.
[0008] In detail, when coefficient of thermal expansion with heat sink 2AP, 2BP and diode 1AP, and IGBT1BP differs, in an above-mentioned soldering portion, the thermal stress according to the temperature gradient from the congealing point of solder occurs. For this reason, the trouble that a crack occurs and advances is in a soldering portion according to the heat cycle by the repeat of the heat cycle (or temperature cycle) and/or the use, and a halt at the time of use of

the power modules 101P-103P (at the time of operation). The crack of such a soldering portion will contract the life of a power module.
[0009] At this time, in order to make above-mentioned thermal stress small, it is possible to thicken solder (for example, 300 micrometers or more). However, by such thickness, the thermal resistance between diode 1AP, etc. and heat sink 2AP and 2BP becomes large, and the separate problem that heat sink 2AP and 2BP must be enlarged is caused.
[0010] Furthermore, by the conventional power modules 101P-103P, if temperature distribution arise in insulating-substrate 5P or base board 9P grade by generation of heat of diode 1AP etc., curvature and a wave will occur in insulating-substrate 5P grade. At this time, when a temperature gradient is large, a crevice is formed between radiation-fin 2P and base board 9P etc. For this reason, between radiation-fin 2P, insulating-substrate 5P, or base board 9P is no longer filled with heat-conduction grease (air entering), and there is a trouble that heat transfer will fall. Moreover, or the crack initiation of an above-mentioned soldering portion is promoted, there is a trouble that a crack advances. Formation of this crevice will reduce the reliability of a power module.
[0011] In order to make it not generate an above-mentioned crevice, the temperature distribution for example, within insulating-substrate 5P grade can be equalized, or it is possible to thicken insulating-substrate 5P grade and to increase rigidity. However, if insulating-substrate 5P grade is thickened, the thermal resistance between insulating-substrate 5P grade, and heat sink 2AP and 2BP will become large, and the separate problem that heat sink 2AP and 2BP must be enlarged also in this case is caused.
[0012] Furthermore, since the property of an element is changed by the temperature rise when diode 1AP and the calorific value of IGBT1BP are large, in order to secure reliability, there is a trouble that the amount of current must be restricted.
[0013] Furthermore, by the conventional power modules 101P-103P, since current transformer 92P and capacitor 8P of a cylindrical shape are separately prepared out of the case of a power module, there is a trouble that the whole module is large-sized. Moreover, the property of current transformer 92P will be enlarged when the current to measure contains many dc components, and according to current transformer 92P, measurement will be performed including the measurement error (about 5%) resulting from the property change by generation of heat.
[0014] Moreover, in power module 103P, the distance of electrode 62P connected to an electrode 61P connected to low voltage side by arrangement position of each power semiconductor device of diode 1A and IGBT1B in power converter with each power semiconductor device and high potential side differs. For this reason, the inductances of wiring of wire 7P grade will differ for every power semiconductor device, consequently output voltage will vary.
[0015] this invention is made in view of this trouble -- having -- small -- it is lightweight and sets it as the main purpose to offer a reliable power module
[0016]
[Means for Solving the Problem] (1) The power module concerning invention according to claim 1 is characterized by having a heat sink, the 1st power semiconductor device soon arranged on the aforementioned heat sink, and the capacitor soon arranged on the aforementioned heat sink.
[0017] (2) The power module concerning invention according to claim 2 is a power module according to claim 1, and the aforementioned heat sink has two or more front faces, and it is characterized by arranging the 1st power semiconductor device of the above, and the aforementioned capacitor on the aforementioned front face where the aforementioned heat sinks differ.
[0018] (3) The power module concerning invention according to claim 3 is a power module according to claim 1 or 2, and the aforementioned heat sink is characterized by having the passage of a refrigerant.
[0019] (4) The power module concerning invention according to claim 4 is a power module according to claim 1 to 3, and it is characterized by for the aforementioned heat sink having had conductivity and the electrode of the 1st power semiconductor device of the above and the electrode of the aforementioned capacitor having pasted it up soon with the aforementioned

heat sink.
[0020] (5) The power module concerning invention according to claim 5 is a power module according to claim 4, and is characterized by having further the insulating substrate arranged on the aforementioned heat sink, and the 2nd power semiconductor device arranged on the aforementioned heat sink through the aforementioned insulating substrate.
[0021] (6) The power module concerning invention according to claim 6 is characterized by having the 2nd power semiconductor device arranged soon on the heat sink of a power module according to claim 4 and others, and a heat sink besides the above.
[0022] (7) The power module concerning invention according to claim 7 is a power module according to claim 6, the heat sink besides the above had conductivity, the electrode of the 2nd power semiconductor device of the above has pasted it up on the heat sink besides the above soon, and the aforementioned power module is characterized by having further the insulating member which insulates a heat sink besides the above from the aforementioned electrode of the aforementioned heat sink and the aforementioned capacitor.
[0023] (8) The power module concerning invention according to claim 8 is a power module according to claim 7, and is characterized by having further the flexible wiring which connects electrically between the 1st power semiconductor device of the above, and the 2nd power semiconductor device of the above, while connecting with the conductive member arranged on the aforementioned insulating member, and the aforementioned conductive member.
[0024] (9) The power module concerning invention according to claim 9 is characterized by having the 1st power semiconductor device arranged soon on the electrode of a capacitor and the aforementioned capacitor.
[0025] (10) The power module concerning invention according to claim 10 is a power module according to claim 9, and the aforementioned electrode of the aforementioned capacitor is characterized by having the passage of a refrigerant.
[0026] (11) The power module concerning invention according to claim 11 is a power module according to claim 9, and is characterized by having further the insulating substrate arranged on the aforementioned electrode of the aforementioned capacitor, and the 2nd power semiconductor device arranged on the aforementioned electrode of the aforementioned capacitor through the aforementioned insulating substrate.
[0027] (12) The power module concerning invention according to claim 12 is a claim 5 or a power module given in either 8 or 11, and the 1st power semiconductor device of the above and the 2nd power semiconductor device of the above are characterized by connecting electrically, for the 1st power semiconductor device of the above accomplishing the lower arm of a power converter, and the 2nd power semiconductor device of the above accomplishing the upper arm of the aforementioned power converter.
[0028] (13) The power module concerning invention according to claim 13 The plurality of the arm of the aforementioned power converter which is a power module according to claim 12, and contains an above top arm and the bottom arm of the above, The 2nd electrode which supplies the 2nd voltage to each 2nd power semiconductor device of the above of the 1st electrode which supplies the 1st voltage to each 1st power semiconductor device of the above of each bottom arm of the above, and each above top arm is included. It is characterized by having further the coaxial line projected and prepared from the arrangement side of the 1st power semiconductor device of the above, or the 2nd power semiconductor device of the above, and for two or more aforementioned arms enclosing the aforementioned coaxial line, and being arranged by abbreviation regular intervals on a concentric circle.
[0029] (14) The power module concerning invention according to claim 14 Two or more heat sinks with which each has the passage of a refrigerant, and two or more power semiconductor devices by which each was carried on the aforementioned heat sink, It is characterized by having the case which has the space which can contain two or more aforementioned heat sinks, for two or more aforementioned heat sinks opening a crevice mutually into the aforementioned space of the aforementioned case, arranging them, and forming the space of the 1 continuation which consists of the aforementioned crevice and the aforementioned passage in the aforementioned space of the aforementioned case.

[0030] (15) The power module concerning invention according to claim 15 is a power module according to claim 14, and is characterized by pouring an insulating refrigerant in the aforementioned passage of the aforementioned heat sink.
[0031]
[Embodiments of the Invention] The typical external view of the power module 101 concerning the gestalt 1 of the operation to <gestalt 1 of operation> drawing 1 is shown. As shown in drawing 1 , the power module 101 is equipped with the power semiconductor device (for example, a freewheeling diode and IGBT) 1 formed in the silicon (Si) substrate, heat sink 2A, an electrode 3, an insulating layer 4, and a wire 7. In addition, in order to avoid complicated-ization of a drawing, detailed illustration-ization of a power semiconductor device 1 is omitted.
[0032] Or especially the power semiconductor device 1 is soon arranged on heat sink 2A, it has touched. a power semiconductor device 1 corresponds to both the principal planes of the above-mentioned silicon substrate -- both -- principal plane 1S1 and 1S2 -- having -- **** -- each -- the electrode (not shown) is formed in principal plane 1S1 and 1S2, respectively and the electrode (it is also hereafter called a rear-face electrode) formed in the rear-face 1S2 concerned when one principal plane (it is also hereafter called rear face) 1S2 put in another way -- the surface 2AS top of the plane of heat sink 2A -- for example, it is soldered
[0033] Here, it is ["the power semiconductor device 1 is soon arranged on heat sink 2A", and] the meaning of "without it minds insulating-substrate 5P which the conventional power modules 101P-103P have, and base board 9P (refer to drawing 34)", and the composition in which the charge of a binder for pasting both up between a power semiconductor device 1 and heat sink 2A (for example, above-mentioned solder) exists is included in the above-mentioned gestalt by which "arranging soon" was carried out. In addition, you may use thermally conductive good adhesives, such as an epoxy resin containing conductive powder, such as aluminum and silver, instead of solder as the above-mentioned charge of a binder.
[0034] Heat sink 2A contains material with almost equal silicon and coefficient of thermal expansion, for example, a (Molybdenum Mo) copper (Cu)-molybdenum (Mo) alloy, a tungsten (W), carbon fiber composite material, etc. Or the aluminum (aluminum) which contained carbon (C) and silicon (Si) (as a material with almost equal silicon and coefficient of thermal expansion) is applied as heat sink 2A. Heat sink 2A has the fin configuration in the opposite side of surface 2AS.
[0035] Furthermore, the insulating layer 4 is arranged on heat sink 2A, and the electrode 3 is arranged on the insulating layer 4. That is, an insulating layer 4 insulates and the electrode 3 is arranged on heat sink 2A. The electrode 3 and the electrode (it is also hereafter called a surface electrode) formed in principal plane (it is also hereafter called front face) 1S1 of another side of a power semiconductor device 1 are electrically connected by the wire 7. In addition, you may connect electrically an electrode 3 and the surface electrode of a power semiconductor device 1 by the pressure welding, the electroconductive glue, etc.
[0036] According to the power module 101, the following effects can be acquired. that is, since the coefficient of thermal expansion of a power semiconductor device 1 and heat sink 2A is almost equal, it differs in the conventional power modules 101P-103P, and it can boil markedly that the crack which originated in the heat cycle at a part for the joint of a power semiconductor device 1 and heat sink 2A (soldering portion) occurs, and can suppress For this reason, it differs in the conventional power modules 101P-103P, there is no need of thickening solder, and thermal resistance between a power semiconductor device 1 and heat sink 2A can be made small. Thereby, a heat sink can be formed into small lightweight.
[0037] Furthermore, since a power semiconductor device 1 and heat sink 2A have touched soon, the temperature gradient between a power semiconductor device 1 and heat sink 2A can be made small. for this reason, the conventional power modules 101P-103P -- differing -- even if -- the inside of rear-face 1S2 of a power semiconductor device 1 -- and/or, even if it is the case where temperature distribution arise in surface 2AS of heat sink 2A, or it generates between rear-face 1S2 and surface 2AS, the thermal stress generated in the charge of a binder between rear-face 1S2 and surface 2AS is small Thereby, the reliability of a power semiconductor device is raised, and according to the power module 101, high reliability can be acquired at a long period

of time.
[0038] The typical external view of the power module 102 concerning the gestalt 2 of the operation to <gestalt 2 of operation> drawing 2 is shown. As shown in drawing 2 , the power module 102 is equipped with freewheeling-diode 1A as a power semiconductor device 1 as stated above and IGBT1B, heat sink 2A, an electrode 3, an insulating layer 4, and a wire 7. In addition, it stops to give the same sign to a thing equivalent to a component as stated above, and use the explanation for.
[0039] freewheeling-diode 1A -- previous statement -- each -- it has surface 1AS1 corresponding to surface 1S1 and rear-face 1S2 and rear-face 1AS2, and a surface electrode and a rear-face electrode (not shown) the same -- IGBT1B -- previous statement -- each -- it has surface 1BS1 corresponding to surface 1S1 and rear-face 1S2 and rear-face 1BS2, and a surface electrode and a rear-face electrode (not shown)
[0040] Especially heat sink 2A of the power module 102 consists of the copper-molybdenum alloy of the material which has conductivity, for example, an above-mentioned material, etc. And diode 1A and IGBT1B make rear-face 1AS2 and 1BS2 meet surface 2AS of heat sink 2A, and are soon arranged on heat sink 2A. Diode 1A and IGBT1B are pasted up by the charge of a binder which has conductivity, for example, solder, on heat sink 2A. Thereby, both the rear-faces electrode of diode 1A and IGBT1B is electrically connected through solder and conductive heat sink 2A. On the other hand, the surface electrode of diode 1A, the surface electrode of IGBT1B, and the electrode 3 are electrically connected by the wire 7.
[0041] Thus, by the power module 102, since heat sink 2A has conductivity (i.e., since heat sink 2A works as an electrode), the number of an electrode 3 and an insulating layer 4 can be cut down, and a power module can be formed into small lightweight.
[0042] In addition, heat sink 2A of the power module 102 has lobe 2AT which continues from surface 2AS, and the insulating layer 4 and the electrode 3 have extended also on lobe 2AT. Thereby, the electrode 3 on lobe 2AT of conductive heat sink 2A and lobe 2AT can be used as a terminal of the power module 102.
[0043] In addition, although the power module 102 is applied to the circuitry from which each rear-face electrode of two or more power semiconductor devices mainly serves as the same potential, two or more power semiconductor devices from which the potential of a rear-face electrode differs can be carried by preparing the insulating substrate (equivalent to conventional insulating-substrate 5P (referring to drawing 34)) which has conductive layers, such as copper foil, between heat sink 2A and a power semiconductor device 1.
[0044] The typical external view of the power module 103 concerning the gestalt 3 of the operation to <gestalt 3 of operation> drawing 3 is shown. As shown in drawing 3 , the power module 103 has the composition with which two power modules 102 were combined and united through insulating member 10. An epoxy resin, injection-molding plastics, etc. are applicable as insulating member 10.
[0045] By the power module 103, it extends to the power module 102 side of another side mutually, and connects with heat sink 2A of the power module 102 of the another side concerned electrically, for example, the electrode 3 of each power module 102 is soldered (lobe 3T reference).
[0046] Since according to the power module 103 two power modules 102 are prepared beforehand and a circuit is constituted combining these, a module can be formed easily. Since the power module 102 by which small lightweight-ization was promoted is used at this time, the power module 103 also turns small lightweight. In addition, you may combine three or more power modules 102.
[0047] In addition, you may connect directly between diode 1A and heat sink 2A with a wire 7 through an electrode 3, for example. In this case, electrode 3 grade is further reducible.
[0048] The typical external view of the power module 104 concerning the gestalt 4 of the operation to <gestalt 4 of operation> drawing 4 is shown. As shown in drawing 4 , the power module 104 is equipped with freewheeling-diode 1A, IGBT1B, conductive heat sink 2B, an electrode 3, an insulating layer 4, and a wire 7.
[0049] Heat sink 2B consists of the same material as above-mentioned conductive heat sink 2A,

and has surface 2BS of the plane corresponding to the above-mentioned surface 2AS. And diode 1A, IGBT1B, and the insulating layer 4 are arranged on the surface 2BS concerned.
[0050] Especially heat sink 2B of the power module 104 has two breakthrough (passage of refrigerant) 2BH as passage of a refrigerant. From surface 2BS, each breakthrough 2BH is put in order and prepared in it in drawing 4 at the longitudinal direction, if it puts in an of-the-same-grade remote position in another way. Moreover, each breakthrough 2BH is formed so that the lower part of diode 1A and IGBT1B may be passed. In addition, breakthrough 2BH may be one or three or more.
[0051] By the power module 104, by pouring liquids, such as gases, such as 6 refrigerant, for example, air, and sulfur fluoride (SF6) and carbon dioxide gas, and water, an oil, FURORINA, to breakthrough 2BH, heat sink 2B is followed and diode 1A and IGBT1B are cooled compulsorily. Thereby, refrigeration capacity can be raised sharply. consequently, a limit of the amount of current currently made in order to secure reliability like the conventional power modules 101P-103P -- relief -- or -- it can cancel -- moreover, a heat sink -- therefore, a power module can be formed into small lightweight
[0052] The typical external view of power module 104A concerning the modification 1 of the gestalt 4 of the operation to <modification 1 of gestalt 4 of operation> drawing 5 is shown. As shown in drawing 5 , it had two above-mentioned power modules 104, breakthrough 2BH of heat sink 2B was connected by piping 2BJ, and both the power module 104 has connected power module 104A.
[0053] If it puts in another way when setting (i) both heat sink 2B as this potential at this time, in setting rear-face electrodes, such as diode 1A on both heat sink 2B, as this potential In insulating between both heat sink 2Bs to (ii) reverse at least at one side of piping and a refrigerant using conductive material and matter (it is hereafter called electric conduction connection) If it puts in another way, in insulating comrades, such as diode 1A on both heat sink 2B, it uses insulating material and matter for the both sides of piping and a refrigerant (it is hereafter called insulating connection).
[0054] If insulating-substrate 5P (and copper foil 6P) (refer to drawing 34) of previous statement are prepared between heat sink 2B, diode 1A, etc. even if it is the case where conductive material and matter are used at least for one side of piping and a refrigerant like the above (iii) (i) at this time, diode 1A etc. can be insulated between both heat sink 2Bs like the above (ii). Conversely, if it says, according to above-mentioned electric conduction connection and above-mentioned insulating connection, it is not necessary to use insulating-substrate 5P grade.
[0055] In addition, three or more power modules 104 may be connected for Piping BJ, and power module 104A may be constituted. In electric conduction connection, at this time, the pump (not shown) for pouring a refrigerant is formed for every group by making into one group two or more power modules 104 set as this potential. On the other hand, what is necessary is just to form one pump to the whole power module 104A in insulating connection.
[0056] The typical external view of power module 104B concerning the modification 2 of the gestalt 4 of the operation to <modification 2 of gestalt 4 of operation> drawing 6 is shown. By power module 104B, as shown in drawing 6 , if two breakthrough 2BH changes and puts the distance from surface 2BS in another way, in drawing 6 , it arranges up and down and is formed.
[0057] Like above-mentioned power module 104A, each breakthrough 2BH of two or more power module 104B may be connected by piping 2BJ, and a circuit may be constituted (refer to drawing 7). At this time, it reaches in upper breakthrough 2BH and lower breakthrough 2BH is connected by piping 2BJ, respectively. By piping so that it may flow, a refrigerant may be turned up after that from upper breakthrough 2BH near diode 1A and IGBT1B and it may flow to lower breakthrough 2BH especially, as compared with the above-mentioned power module 104, the temperature gradient of the refrigerant in each heat sink 2B is absorbed, and more uniform refrigeration capacity is obtained.
[0058] The typical external view of power module 104C concerning the modification 3 of the gestalt 4 of the operation to <modification 3 of gestalt 4 of operation> drawing 8 is shown. As shown in drawing 8 , power module 104C is equipped with the two above-mentioned power

modules 104, and both the power module 104 is arranged in contact with surface 2BS of heat sink 2B in the front faces of an opposite side.
[0059] The typical external view of power module 104D concerning the modification 4 of the gestalt 4 of the operation to <modification 4 of gestalt 4 of operation> drawing 9 is shown. As shown in drawing 9 , power module 104D is equipped with the two above-mentioned power modules 104, and both the power module 104 is accumulated up and down through the supporter material 15. this time -- (i) -- if conductive members, such as a metal, are used for at least one supporter material 15 -- both heat sink 2B -- this potential -- it can set up -- (ii) -- if insulating member, such as a resin, is used for all the supporter material 15, between both heat sink 2Bs can be insulated
[0060] The typical external view (a plan and side elevation) of the power module 105 applied to the gestalt 5 of operation at <gestalt 5 of operation> drawing 10 and drawing 11 is shown. In addition, drawing 11 is omitting illustration-ization of a part of component in drawing 11 , in order to avoid complicated-ization of a drawing in the external view at the time of seeing the power module 105 from the direction of the arrow A in drawing 10 . Moreover, typical drawing of longitudinal section of the power module 105 is shown in drawing 12 .
[0061] The power module 105 accomplishes the so-called voltage type power converter of a three phase circuit. In addition, an inverter and a converter are included with a power converter. In a power converter, the upper arm and lower arm which accomplish a pair mutually and form an arm are connected in series through an output terminal for every phase, an upper arm is connected between output terminals a high potential (it corresponds to 2nd voltage) side, and a lower arm is connected between an output terminal and a low voltage (it corresponds to 1st voltage) side (or grounded). That is, the power converter has accomplished the polyphase bridge circuit (here three-phase-circuit bridge circuit) in equal circuit.
[0062] The power module 105 is equipped with heat sink 2C of the cylindrical shape which has circular principal plane (front face) 2CS1 which counters, and 2CS2. Heat sink 2C has conductivity.
[0063] Three insulating substrates 50U, 50V, and 50W which consist of a ceramic board are arranged on one principal plane 2CS1 of heat sink 2C. Copper foil is formed on both the principal planes of each insulating substrates 50U, 50V, and 50W, and insulating substrates 50U, 50V, and 50W are pasted up on principal plane 2CS1 with solder. At this time, the above-mentioned copper foil which meets heat sink 2C is for performing adhesion between insulating substrates 50U, 50V, and 50W and heat sink 2C good. On the other hand, each copper foil which does not meet heat sink 2C on each insulating substrates 50U and 50V and 50W accomplishes each electrodes 60U, 60V, and 60W which are equivalent to the output terminal of a power converter. For this reason, you may use electrical conducting materials other than copper foil as electrodes 60U, 60V, and 60W.
[0064] Especially the insulating substrates 50U, 50V, and 50W are arranged at abbreviation regular intervals on the periphery of circular principal plane 2CS1, and the periphery of this heart. If it puts in another way, only the distance same from the above-mentioned center on the radiation accomplished and specified leaves the same angle (here 120 degrees) mutually to the center of circular principal plane 2CS1, and insulating substrates 50U, 50V, and 50W are arranged.
[0065] Furthermore, the group of the power semiconductor device which consists of one diode each 1A and IGBT1B adjoins 3 sets and insulating substrates 50U, 50V, and 50W, and is soon arranged on principal plane 2CS1. Each class of an above-mentioned power semiconductor device is arranged at abbreviation regular intervals again at the periphery [of circular principal plane 2CS1], and periphery top of this heart between the arrays of each above-mentioned insulating substrates 50U, 50V, and 50W. Especially each rear-face electrode of this diode 1A and IGBT1B is soon pasted up on principal plane 2CS1 with solder. On the other hand, each surface electrode of diode 1A and IGBT1B is electrically connected to Electrodes 60U, 60V, and 60W by the wire 7. Thus, each class of 3 sets of diode 1A and IGBT1B by which direct attachment is carried out on heat sink 2C constitutes the lower arm of a power converter.
[0066] Furthermore, the insulating substrate 5 which consists, for example of a ceramic board

approaches insulating substrates 50U, 50V, and 50W, and is arranged on principal plane 2CS1. Each insulating substrate 5 is arranged at abbreviation regular intervals again at the periphery [of circular principal plane 2CS1], and periphery top of this heart between the arrays of each above-mentioned insulating substrates 50U, 50V, and 50W. Copper foil is formed on both the principal planes of each insulating substrate 5, and each insulating substrate 5 is pasted up on principal plane 2CS1 with solder. The copper foil of the side which does not meet heat sink 2C accomplishes a conductive layer 6.

[0067] Diode 1A and IGBT1B are arranged on the conductive layer 6 of each insulating substrate 5. Diode 1A and IGBT1B made each rear-face electrode meet a conductive layer 6, for example, are pasted up with solder. Moreover, the adjoining conductive layer 6 and Electrodes 60U, 60V, and 60W are connected by the wire 7. 3 sets of diode 1A arranged on heat sink 2C through the insulating substrate 5, and IGBT1B -- each constitutes the upper arm of a power converter

[0068] According to the starting arrangement, such as diode 1A, three arms (it consists of an upper arm and a lower arm) which the power module 105 has enclose the circular center (an electrode 61 is arranged like the after-mentioned) concerned of circular principal plane 2CS1 of heat sink 2C, and are arranged by abbreviation regular intervals on the concentric circle.

[0069] And insulating-substrate 50C which consists for example, of a ceramic board near [concerned / circular] a center on circular principal plane 2CS1 is arranged. On both the principal planes of insulating-substrate 50C, copper foil is formed, for example, and insulating-substrate 50C is pasted up on principal plane 2CS1 with solder. The copper foil which does not meet heat sink 2C accomplishes conductive-layer 60C. Each surface electrode of diode 1A on an insulating substrate 5 and IGBT1B is electrically connected with conductive-layer 60C by the wire 7. In addition, configurations, such as insulating-substrate 50C and conductive-layer 60U, are not restricted to the configuration illustrated by drawing 10 etc.

[0070] Especially, it pierced through insulating-substrate 50C from the abbreviation center of circular principal plane 2CS1 which is installation sides, such as diode 1A, for example, the cylindrical electrode 61 is extended (refer to drawing 12). The electrode 61 is electrically connected with heat sink 2C. Moreover, it connects with conductive-layer 60C electrically, and the electrode 62 is arranged. An electrode 62 consists of a tubed electrode and the electrode 61 is inserted in the tubed interior. Insulating member 11 is arranged between an electrode 61 and 62, and two electrodes 61 and 62 are insulated. Electrodes 61 and 62 accomplish the so-called coaxial line. In addition, by the power module 105, an electrode 62 is [an electrode 61] equivalent to "the 2nd electrode" in "the 1st electrode."

[0071] By such composition, the power module 105 has accomplished the power converter which has five electrodes 60U, 60V, 60W, 61, and 62.

[0072] Here, the ** type view for explaining to drawing 13 breakthrough 2CH which heat sink 2C has is shown. In addition, drawing 13 is a drawing equivalent to drawing 10 , and in order to avoid complicated-ization of a drawing, illustration-ization of the insulating-substrate 5 grade in drawing 10 is omitted. As shown in drawing 13 , three breakthrough 2CH(s) of the shape of an abbreviation ring of the periphery of principal plane 2CS1 and this heart are formed in heat sink 2C (various dashed lines show each). each -- the power module 105 is cooled by pouring a refrigerant to breakthrough 2CH Although the number of breakthrough 2CH is not restricted to three, it is desirable that diode 1A which is a heating element, and IGBT1B prepare breakthrough 2CH caudad. Moreover, you may prepare breakthrough 2CH for example, the shape not of a ring but in the shape of a whorl. Moreover, you may prepare breakthrough 2CH in piles up and down between principal plane 2CS1 and 2CS2 like power module 104B (refer to drawing 6).

[0073] According to the power module 105, as mentioned above, three arms of a power converter enclose the above-mentioned coaxial line, and are arranged by abbreviation regular intervals on the concentric circle. For this reason, since wiring between electrodes 61 and 62 and each arm can be formed similarly, while being able to make small dispersion in each output taken out from each arm, since change by the side of low voltage can be made small, it can be made strong to a malfunction. Consequently, a reliable power converter can be offered.

[0074] Although all diode 1A etc. has been arranged on principal plane 2CS1 of heat sink 2C by the <modification 1 of the gestalt 5 of operation>, in addition the power module 105, you may

arrange the part on principal plane 2CS2 of another side of sheet sink 2C. For example, the component arranged on three insulating substrates 5 and it may be arranged on principal plane 2CS2, and predetermined wiring may be performed.
[0075] The typical external view of the power module 111 concerning the gestalt 6 of the operation to <gestalt 6 of operation> drawing 14 is shown. As shown in drawing 14 , by the power module 111, the capacitor or capacitor 20 for diode 1A, IGBT1B, and direct-current smooth is soon arranged on surface 2BS of conductive heat sink 2B of the previous statement which has breakthrough 2BH. In addition, diode 1A and IGBT1B hit "the 1st power semiconductor device", respectively.
[0076] Diode 1A has both the principal planes (surface 1AS1 and rear-face 1AS2) corresponding to both the principal planes of a silicon substrate like previous statement, a surface electrode is formed in surface 1AS1, and the rear-face electrode is formed in rear-face 1AS2 again. A surface electrode is formed in surface 1BS1, and the rear-face electrode is formed [in / IGBT1B / similarly] in rear-face 1BS2 again. in order [in addition,] to avoid complicated-ization of a drawing -- drawing 14 -- diode 1A and IGBT1B -- detailed illustration-ization of each surface electrode and a rear-face electrode is omitted
[0077] Especially, it differs in capacitor 8P of the conventional cylindrical shape, and a capacitor 20 consists of the capacitor of a monotonous form which has two principal plane 20S1 which counters, and 20S2. And the electrode (it does not illustrate but is also called; rear-face electrode) is formed in one principal plane (it is also hereafter called rear face) 20S2 of a monotonous form, and the electrode (it does not illustrate but is also called; surface electrode) is formed in principal plane (it is also hereafter called front face) 20S1 of another side.
[0078] Heat sink 2B has pasted up diode 1A, IGBT1B, and each rear-face electrode of a capacitor 20 on heat sink 2C with solder. Thereby, each rear-face electrodes are electrically connected through conductive heat sink 2B. On the other hand, diode 1A, IGBT1B, and each surface electrodes (heat sink 2B is not met) of a capacitor 20 are connected by the wire 7. In addition, you may connect between each surface electrode electrically by the pressure welding, the electroconductive glue, etc.
[0079] According to the power module 111, the following effects can be acquired. first, small -- it is lightweight and the reliable power module 111 can be offered
[0080] In detail, direct attachment of diode 1A, IGBT1B, and the capacitor 20 is carried out on heat sink 2C. For this reason, these can miniaturize a power module rather than the conventional power modules 101P-103P formed separately. Moreover, since not only generation of heat of diode 1A and IGBT1B but the temperature rise of a capacitor 20 can be suppressed by thermolysis operation of heat sink 2C, miniaturization of a capacitor 20, reduction in an inductance, and reinforcement can be attained.
[0081] Furthermore, since direct attachment of diode 1A, IGBT1B, and the capacitor 20 is carried out on heat sink 2C, the length of the wiring which connects between diode 1A and IGBT1B, and capacitors 20 can be made shorter than the conventional power modules 101P-103P. Since especially heat sink 2C has conductivity, as for diode 1A, IGBT1B, and the capacitor 20, heat sink 2C is electrically connected with the shortest path. For this reason, a circuit inductance can be reduced rather than the conventional power modules 101P-103P. Therefore, the jumping voltage (overshoot) produced at the time of the switching operation of diode 1A and IGBT1B can be reduced, consequently pressure-proofing and loss of diode 1A and IGBT1B can be reduced. moreover, a wire length -- short -- a bird clapper -- originating -- electromagnetism -- generating of a noise can be reduced
[0082] Moreover, according to the power module 111, since heat sink 2C has conductivity, the heat sink 2C concerned can be used as an electrode. for this reason -- for example, part mark, such as wiring required in the case of an insulating heat sink, and the formation process of that are reducible
[0083] In addition, the refrigeration capacity of heat sink 2B can be improved by pouring a refrigerant to breakthrough 2BH of heat sink 2B.
[0084] Even if it applies conductive heat sink 2A which has fin structure like power module 111A which is <the modification 1 of the form 6 of operation>, and which changes into heat sink 2B

and is shown in drawing 15 , an above-mentioned effect can be acquired.
[0085] You may arrange the <modification 2 of the form 6 of operation> and a capacitor 20, diode 1A, and IGBT1B on the front face on which heat sink 2Bs differ. Specifically, like power module 111B shown in drawing 16 , while arranging diode 1A and IGBT1B on surface 2BS of heat sink 2B, you may arrange a capacitor 20 on other surface (side) 2Bs S3 which cross the above-mentioned surface 2BS. Moreover, you may arrange on the above-mentioned surface 2BS and surface 2B S2 which counters. Such composition can be applied when using heat sink 2A.
[0086] According to power module 111B, as compared with the above-mentioned power module 111, a power module can be further formed into small lightweight. Moreover, since interference with thermolysis of diode 1A and IGBT1B and thermolysis of a capacitor 20 decreases, thermolysis nature can be improved.
[0087] The typical external view of the power module 112 concerning the gestalt 7 of the operation to <gestalt 7 of operation> drawing 17 is shown. The power module 112 is changed into a capacitor 20 (refer to drawing 14), and is equipped with the dielectric 33 for capacitors, and the electrode 31 for capacitors so that it may understand, if drawing 17 is compared with drawing 14 as stated above. In detail, the dielectric 33 for capacitors is put by conductive heat sink 2B and the conductive electrode 31 for capacitors, and the capacitor 30 of a monotonous form which is with heat sink 2B, the dielectric 33 for capacitors, and the electrode 31 for capacitors, with is equivalent to the above-mentioned capacitor 20 is constituted. Other composition is the same as that of the power module 111.
[0088] In the electrode 31 for capacitors, at this time, heat sink 2B is equivalent to this rear-face electrode in the surface electrode of a capacitor 20. For this reason, by the power module 112, if diode 1A and IGBT1B are arranged on the rear-face electrode of a capacitor 30, it can catch.
[0089] According to the power module 112, the same effect as the above-mentioned power module 111 is acquired.
[0090] You may apply conductive heat sink 2A which has fin structure like power module 112A which is <the modification 1 of the gestalt 7 of operation>, and which changes into heat sink 2B and is shown in drawing 18 .
[0091] The typical external view of power module 112B concerning the modification 2 of the gestalt 7 of the operation to <modification 2 of gestalt 7 of operation> drawing 19 is shown. In power module 112B, the dielectric 32 for capacitors and the electrode 31 for capacitors are arranged like power module 111B (refer to drawing 16) on surface 2B S2 of a different heat sink 2B from surface 2BS, and surface 2B S3. Such composition can be applied when using heat sink 2A. According to power module 112B, the same effect as above-mentioned power module 111B is acquired.
[0092] The typical external view of power module 111C concerning the gestalt 8 of the operation to <gestalt 8 of operation> drawing 20 is shown. Power module 111C accomplishes the so-called voltage type power converter of a three phase circuit.
[0093] In power module 111C, a capacitor 20 makes the rear-face 20S2 meet above-mentioned surface 2B S2 of heat sink 2B, and is soon arranged on heat sink 2B.
[0094] Power module 11C is equipped with three arms of a power converter. Both one diode each 1A and IGBT1B that accomplish the lower arm of each arm make a rear-face electrode meet heat sink 2B, and are soon arranged on surface 2BS of heat sink 2B. Moreover, each surface electrode of diode 1A of each lower arm and IGBT1B is electrically connected to the electrodes 60U, 60V, and 60W which accomplish the output terminal of a power converter, respectively by the wire 7. In addition, each electrodes 60U, 60V, and 60W are arranged on surface 2BS of heat sink 2B through each insulating substrates (or each insulating layer) 50U, 50V, and 50W.
[0095] On the other hand, one diode each 1A and IGBT1B (each hits the 2nd power semiconductor device) which accomplish the upper arm of each arm are arranged on surface 2BS of heat sink 2B through the insulating substrate 5. At this time, the rear-face electrode of diode 1A of an upper arm and IGBT1B is electrically connected with the conductive layer 6 on an insulating substrate 5. Each conductive layer 6 is electrically connected to the electrodes

60U, 60V, and 60W for each arms by the wire 7. Each surface electrode of diode 1A which accomplishes an upper arm, and IGBT1B is electrically connected to the electrode 61 common to all arms by the wire 7.
[0096] An electrode 61 extends even from surface 2B[of heat sink 2B] S to surface 20S1 of a capacitor 20, and is electrically connected to the surface electrode of a capacitor 20. In addition, the electrode 61 is insulated with portions other than the surface electrode of a capacitor 20, and heat sink 2B by the insulating layer 50.
[0097] In addition, in power module 111C, heat sink 2B is equivalent to the "1st electrode" connected to a low voltage side in the "2nd electrode" by which an electrode 61 is connected to a high potential side.
[0098] According to power module 111C, diode 1A and IGBT1B of an upper arm are arranged on heat sink 2B through the insulating substrate 5. For this reason, on conductive heat sink 2B, diode 1A and IGBT1B from which the potential of a rear-face electrode differs can be made intermingled, and a circuit can be formed.
[0099] The typical external view of power module 112C concerning the modification 1 of the gestalt 8 of the operation to <modification 1 of gestalt 8 of operation> drawing 21 is shown. Power module 112C accomplishes the so-called voltage type power converter of a three phase circuit like above-mentioned power module 111C.
[0100] Power module 112C is changed into the capacitor 20 of power module 111C, and is equipped with the electrode 31 for capacitors, and the dielectric 33 for capacitors so that it may understand, if drawing 21 is compared with drawing 20 as stated above. In detail, the dielectric 33 for capacitors meets surface 2B S2 of heat sink 2B, is arranged, and is inserted by heat sink 2B and the electrode 31 for capacitors. Thereby, it is with heat sink 2B, the dielectric 33 for capacitors, and the electrode 31 for capacitors, with the capacitor 30 of an above-mentioned monotonous form is constituted. Other composition is the same as that of power module 111C.
[0101] According to power module 112C, it will be caught if diode 1A and IGBT1B are arranged on one electrode of a capacitor 30, and the same effect as the power module 112 can be acquired. Moreover, diode 1A and IGBT1B from which the potential of a rear-face electrode differs by the insulating substrate 5 can be made intermingled on the electrode of a capacitor 30 like the above-mentioned power module 111C.
[0102] The typical external view of the power module 113 concerning <form 9 of operation> drawing 22 and the form 9 of the operation to drawing 23 is shown. Drawing 23 is equivalent to the external view (side elevation) at the time of seeing the power module 113 from the direction of the arrow A in drawing 22 . In addition, in order to avoid complicated-ization of a drawing, in drawing 23 , diode 1A, IGBT1B, and illustration-ization of a wire 7 are omitted. The power module 113 accomplishes the so-called voltage type power converter of a three phase circuit like above-mentioned power module 111C.
[0103] By the power module 113, all diode 1A and IGBT1B of a lower arm of a power converter are soon arranged on surface 2BS of one heat sink 2B for lower arms so that it may understand, if drawing 22 is compared with drawing 20 as stated above. And heat sink 2B and a capacitor 20 make surface 2B S2 and rear-face 20S2 meet, and are arranged, and heat sink 2B and the rear-face electrode of a capacitor 20 have touched electrically.
[0104] on the other hand, diode 1A and IGBT1B of each up arm of a power converter are soon arranged on heat sink (others -- heat sink) 2B which has the conductivity for each up arms, and are electrically connected with the electrode 61 like power module 111C (refer to drawing 20) insulating connection of the three heat sink 2Bs for each up arms is carried out mutually -- **** (illustration-ization of piping 2BJ is omitted in drawing 22) -- insulating member 10 insulates with heat sink 2B for lower arms, and the rear-face electrode of a capacitor 20 In addition, it is insulating member 10, with four heat sink 2Bs and capacitors 20 have joined together in one.
[0105] Heat sink 2B for each up arms is electrically connected by the wire 7 with Electrodes 60U, 60V, and 60W and the wire (flexible wiring) 7 for each arms. Especially the wire 7 concerned has connected the upper arm and the lower arm electrically by making into the point acting as intermediary or a point [course] the portion (conductive member) arranged on insulating

member 10 among Electrodes 60U, 60V, and 60W.
[0106] As mentioned above, by the power module 113, it is insulating member 10, with four heat sink 2Bs are insulated mutually. For this reason, the potential of the rear-face electrode of diode 1A for upper arms and IGBT1B and this rear-face electrode for lower arms can be changed, without using an insulating substrate 5 unlike power module 111C (referring to drawing 20) as stated above. For this reason, only the part of an insulating substrate 5 can cut down part mark.
[0107] Furthermore, by the power module 1113, since both the composition of an upper arm and a lower arm is profile EQCs, the manufacturing cost of the whole power module can be reduced. Consequently, the cheap power module 113 can be offered.
[0108] Moreover, the wire 7 which connects an upper arm and a lower arm as mentioned above is connected to the portion (conductive member) arranged on insulating member 10 among Electrodes 60U, 60V, and 60W. For this reason, as compared with the case where between an upper arm and lower arms is directly connected through the above-mentioned conductive member, the wiring concerned bends or a lappet can be pressed down. Consequently, the short circuit by the lappet of wiring can be prevented.
[0109] The typical external view (side elevation) and typical drawing of longitudinal section of power module 111D concerning <gestalt 10 of operation> drawing 24 and the gestalt 10 of the operation to drawing 25 are shown. Since power module 111D has the composition which formed the capacitor 20 in the power module 105 as stated above fundamentally so that it may understand, if drawing 24 is compared with drawing 11 as stated above, it stops to use explanation as stated above for about the same composition as the power module 105, and explanation is advanced focusing on the feature portion of power module 111D. In addition, in drawing 24 , illustration-ization of a part of component is omitted like drawing 11 .
[0110] In addition, three lower arms of a power converter are constituted from diode 1A and IGBT1B by which direct attachment is carried out by heat sink 2C, respectively, and three upper arms of a power converter consist of diode 1A and IGBT1B which are arranged on heat sink 2C through the insulating substrate 5, respectively.
[0111] As for power module 111D, the capacitor 20 is soon arranged on circular principal plane 2CS2 of conductive heat sink 2C. At this time, a capacitor 20 makes the rear-face 20S2 meet heat sink 2C, and is arranged, and the rear-face electrode 20E2 (refer to drawing 25) of a capacitor 20 and heat sink 2C are connected electrically.
[0112] In power module 111D, the topologies of electrodes 61 and 62 differ especially in the power module 105 as stated above. In detail, as shown in drawing 25 , the cylindrical electrode 61 pierces through heat sink 2C and a capacitor 20 (except for a surface electrode 20E1), extends, and is electrically connected with the surface electrode 20E1 of a capacitor 20. At this time, insulating member 11 is also elongated with the electrode 61, and the electrode 61 is insulated from heat sink 2C and the capacitor 20 (except for a surface electrode 20E2). On the other hand, the tubed electrode 62 pierces through insulating-substrate 50C, is arranged, and is electrically connected with heat sink 2C.
[0113] In power module 111D, an electrode 62 is equivalent to the "1st electrode" connected to a low voltage side in the "2nd electrode" by which an electrode 61 is connected to the high potential side of a power converter.
[0114] While according to power module 111D originating in arrangement of three arms which enclose a coaxial line like the power module 105 as stated above and being able to offer a reliable power converter, a lightweight power converter smaller than conventional power module 103P can be offered.
[0115] The typical external view and typical drawing of longitudinal section of power module 112D concerning the modification 1 of <modification 1 of gestalt 10 of operation> drawing 26 and the gestalt 10 of the operation to drawing 27 are shown. Power module 112D accomplishes the so-called voltage type power converter of a three phase circuit like above-mentioned power module 111D.
[0116] Power module 112D is changed into the capacitor 20 of power module 111D, and is equipped with the electrode 31 for capacitors, and the dielectric 33 for capacitors so that it may understand, if drawing 26 is compared with drawing 24 as stated above. In detail, the dielectric 33

for capacitors meets principal plane 2CS2 of heat sink 2C, is arranged, and is inserted by heat sink 2B and the electrode 31 for capacitors. Thereby, it is with heat sink 2B, the dielectric 33 for capacitors, and the electrode 31 for capacitors, with the capacitor 30 of an above-mentioned monotonous form is constituted. And like power module 111D, the cylindrical electrode 61 of power module 112D pierces through heat sink 2C and the dielectric 33 for capacitors, extends, and is electrically connected with the electrode 31 for capacitors. Other composition is the same as that of power module 111D. For this reason, the same effect as power module 111D can be acquired.

[0117] Moreover, in power module 112D, it will be caught if diode 1A and IGBT1B are arranged on the rear-face electrode of a capacitor 30, and the same effect as the power module 112 can be acquired.

[0118] The ** type view of power module 111E concerning the gestalt 11 of the operation to <gestalt 11 of operation> drawing 28 - drawing 30 is shown. In addition, since it is based on above-mentioned power module 111D, and in order that power module 111E may avoid complicated-ization of a drawing, it omits illustration-ization of some wires 7 in drawing 28 , and is omitting illustration-ization of Electrodes 60U and 60V and 60W grade by drawing 29 and drawing 30 again.

[0119] To all of diode 1A and IGBT1B being arranged on one principal plane 2CS1 of heat sink 2C, by power module 111E, diode 1A and IGBT1B distribute to principal plane 2CS1 of heat sink 2C, and surface 20S1 of a capacitor 20, and are arranged at above-mentioned module 111D.

[0120] Diode 1A and IGBT1B which accomplish the lower arm of a power converter in detail on principal plane 2CS1 of heat sink 2C which has conductivity are arranged soon (refer to drawing 29). And the surface electrodes of concerned diode 1A and IGBT1B are connected. on the other hand, the insulating substrate 5 is arranged on surface 20S1 of a capacitor 20 (detailed -- a surface electrode top), and diode 1A and IGBT1B which accomplish the upper arm of a power converter on the conductive layer 6 of an insulating substrate 5 are arranged (refer to drawing 30) The surface electrode of diode 1A on an insulating substrate 5 and IGBT1B is connected to heat sink 2C.

[0121] Furthermore, the rear-face electrode of IGBT1B of an upper arm, the conductive layer 6 through which it flows, and the surface electrode of IGBT1B of a lower arm are connected, and the arm of a power converter is accomplished (refer to wiring 7B). The above-mentioned node in three arms accomplishes Electrodes 60U, 60V, and 60W. The same effect as power module 111D is acquired by power module 111E.

[0122] In addition, in power module 111E, heat sink 2C is connected to a low voltage side, and the surface electrode of a capacitor 20 is connected to a high potential side. Although illustration-ization to drawing 28 - drawing 30 is omitted at this time, electric power may be supplied by the coaxial line (refer to drawing 25) which has the same topology as power module 111D, and, in this case, an electrode 61 hits [an electrode 62] in "the 1st electrode" at "the 2nd electrode."

[0123] Moreover, you may change the capacitor 20 of power module 111E into the dielectric 33 for capacitors, and the electrode 31 for capacitors like the relation between above-mentioned power module 111D and power module 112D.

[0124] The typical external view of the power module 201 concerning the form 12 of the operation to <form 12 of operation> drawing 31 is shown. The power module 201 is equipped with the insulating case 202 which has two crevice (space) 202K. Heat sink 2B by which direct attachment of heat sink 2B by which direct attachment of the diode 1A was carried out, and the IGBT1B was carried out into each crevice 202K of a case 202 is arranged in by turns, and is contained by one train. In addition, in drawing 31 , illustration-ization of connection of diode 1A and IGBT1B is omitted.

[0125] Under the present circumstances, in each crevice 202K, each heat sink 2B leaves a crevice 203, it is arranged, and the sense of each heat sink 2B or breakthrough 2BH is set that between each crevice 203 is spatially connected by breakthrough 2BH of heat sink 2B. moreover -- each -- heat sink 2B and the size of crevice 202K are specified so that any crevices other than crevice 203 may not be made between the inside of crevice 202K, and heat sink 2B

[0126] In each crevice 202K, the crevice 203 is established in the ends of the list of heat sink 2B, and the hole connected with each crevice 203 concerned is formed in each case 202. and -- each -- piping 2BJ is connected to the hole of one way each of crevice 202K, respectively, the hole of each another side is mutually connected by piping 2BJ, and crevice 202K comrades are connected

[0127] the insulating lid (not shown) which is a part of case 202 covers a crevice 203 -- having -- getting down -- thereby -- both -- so to speak, crevice 202K accomplish the space of 1 continuation For this reason, by the power module 201, a refrigerant can be slushed from one hole of above-mentioned one [of crevice 202K], and a refrigerant can be poured in both crevice 202K. Since both the case 202 and the above-mentioned lid are insulation at this time, if an insulating refrigerant is used, for example, between each heat sink 2B can be insulated (insulating connection). In addition, liquids, such as gases, such as 6 air, sulfur, etc. fluoride (SF6), and an oil, FURORINA, are mentioned as an insulating refrigerant. Moreover, if a conductive refrigerant is used, for example, conductive heat sink 2Bs can be set as this potential (electric conduction connection). Moreover, insulating heat sink 2B and conductive heat sink 2B are combined, and if a conductive refrigerant is used, electric conduction connection only of the desired conductive heat sink 2B can be carried out.

[0128] Now, diode 1A and/or IGBT1B may be arranged on heat sink 2B through an insulating substrate 5, and even if it is the case where conductive heat sink 2B is used in this case, desired diode 1A and/or desired IGBT1B can be insulated from others. Conversely, if it says, an insulating substrate 5 can be made unnecessary by the conductivity/insulation of heat sink 2B as mentioned above. In addition, you may arrange two or more power semiconductor devices on one heat sink 2B.

[0129] As mentioned above, since each heat sink 2B leaves a crevice 203 and is put in order, a refrigerant passes breakthrough 2BH narrower than a crevice 203 and a crevice 203 by turns. If it puts in another way when a refrigerant passes along breakthrough 2BH at this time, when it passes along the lower part of diode 1A which is a heating element, and IGBT1B, a refrigerant flows quickly rather than the time of passing along a crevice 203. Thereby, the cooling effect can be increased. On the other hand, since the flow of the refrigerant in the crevice section 203 is later than it in breakthrough 2BH, pressure loss can be suppressed. Therefore, according to the power module 201, it is lower pressure loss, with a higher cooling performance can be realized.

[0130] Moreover, if it puts in another way, even if it will be the case where diode 1A and/or IGBT1B are soon arranged on conductive heat sink 2B, without using an insulating substrate 5 by using an insulating refrigerant as mentioned above, each power semiconductor device can be insulated mutually. For this reason, only the part of an insulating substrate 5 can cut down part mark by using an insulating refrigerant. Furthermore, since each heat sink 2B which carried diode 1A and/or IGBT1B is an outline EQC, respectively, the manufacturing cost and price of the whole power module can be reduced.

[0131] Furthermore, it originates in each above-mentioned power semiconductor device being insulated mutually, and each power semiconductor device can be soon arranged on conductive heat sink 2B. Therefore, the heat dissipation performance of a power module can be improved, consequently reliability can be raised.

[0132] The typical external view of the power module 114 concerning the form 13 of the operation to <form 13 of operation> drawing 32 is shown. As shown in drawing 32 , the power module 114 is further equipped with the shunt resistance 90 for amperometries to the power module 113 shown in drawing 22 as stated above. In detail, the shunt resistance 90 is directly connected to the outgoing end of Electrodes 60U, 60V, and 60W, respectively, and each shunt resistance 90 has accomplished each output terminal of a power converter.

[0133] Since current is measured by shunt resistance by the power module 114, it differs in current transformer 92P used in the conventional power module 101P grade, and a control power source is unnecessary and there is no offset theoretically.

[0134] Moreover, since it connects with the outgoing end of Electrodes 60U, 60V, and 60W directly, as compared with the conventional power module 101 grade by which current transformer 92P are separately prepared out of the case, the shunt resistance 90 can form the

whole power module into small lightweight, and can cut down the mark of the parts for current measurement.
[0135] The typical external view of power module 114A concerning the modification 1 of the form 13 of the operation to <modification 1 of form 13 of operation> drawing 33 is shown. Each shunt resistance 90 of power module 114A is formed in the position which meets surface 2BS of heat sink 2B, and is directly connected with each electrodes 60U, 60V, and 60W so that it may understand, if drawing 33 is compared with above-mentioned drawing 32 .
[0136] According to power module 114A, the temperature rise of the shunt resistance 90 can be suppressed by operation of a heat sink 90. For this reason, property change of the shunt resistance resulting from the temperature change can be suppressed sharply, consequently the detection precision of the amount of current can be improved further. Moreover, since the shunt resistance 90 is arranged above heat sink 2B, as compared with the above-mentioned power module 114, it can miniaturize further.
[0137]
[Effect of the Invention] (1) According to invention concerning a claim 1, direct attachment of the 1st power semiconductor device and capacitor both is carried out on the heat sink. For this reason, both can form a power module into small lightweight rather than the conventional power module formed separately. Moreover, since not only generation of heat of the 1st power semiconductor device but the temperature rise of a capacitor can be suppressed by heat dissipation operation of a heat sink, miniaturization of a capacitor, reduction in an inductance, and reinforcement can be attained.
[0138] Furthermore, since direct attachment of the 1st power semiconductor device and capacitor both is carried out on the heat sink, it can be made shorter than the conventional power module above-mentioned [the length of the wiring which connects between both]. For this reason, a circuit inductance can be reduced. Therefore, the jumping voltage (overshoot) produced at the time of the switching operation of the 1st power semiconductor device can be reduced, consequently pressure-proofing and loss of the 1st of a power semiconductor device can be reduced. moreover, a wire length -- short -- a bird clapper -- originating -- electromagnetism -- generating of a noise can be reduced
[0139] therefore, small -- it is lightweight and a reliable power module can be offered
[0140] (2) According to invention concerning a claim 2, since the 1st power semiconductor device and capacitor are arranged on the front face where heat sinks differ, they can form a power module into small lightweight further as compared with the case where both are stationed on the same front face. Moreover, since interference with heat dissipation of the 1st power semiconductor device and heat dissipation of a capacitor decreases, heat dissipation nature can be improved.
[0141] (3) According to invention concerning a claim 3, the refrigeration capacity of a heat sink can be further improved by pouring a refrigerant to the passage of a heat sink.
[0142] (4) According to invention concerning a claim 4, since a heat sink has conductivity, a heat sink can be used as an electrode. For this reason, part mark, such as wiring on a heat sink, and the formation process of that are reducible, for example.
[0143] Furthermore, the electrode of the 1st power semiconductor device and the electrode of a capacitor have pasted up soon with the heat sink. That is, the 1st power semiconductor device and capacitor are electrically connected through the heat sink. For this reason, electrical installation between two electrodes can be further shortened rather than the case where between two electrodes is connected with wiring of a wire etc. consequently, by further reduction of a circuit inductance, the above-mentioned jumping voltage (overshoot) etc. can be boiled markedly, and can be reduced
[0144] (5) According to invention concerning a claim 5, the 2nd power semiconductor device is arranged on the heat sink through the insulating substrate. For this reason, on a conductive heat sink, the power semiconductor device from which potential differs can be arranged, and a circuit can be constituted.
[0145] (6) According to invention concerning a claim 6, it has further the 2nd power semiconductor device arranged on other heat sinks. For this reason, combination can constitute

a circuit for the 1st power semiconductor device and 2nd power semiconductor device easily.
[0146] (7) According to invention concerning a claim 7, the potential of the 1st power semiconductor device and the 2nd power semiconductor device can be changed, without using an insulating substrate, since other conductive heat sinks are insulated from the above-mentioned conductive heat sink and the electrode of a capacitor by insulating member. For this reason, only the part of an insulating substrate can cut down part mark. Furthermore, since the composition containing the 1st power semiconductor device and heat sink and the composition containing the 2nd power semiconductor device and heat sink are outline EQCs, the manufacturing cost of the whole power module can be reduced. Consequently, a cheap power module can be offered.
[0147] (8) According to invention concerning a claim 8, the 1st power semiconductor device and 2nd power semiconductor device are electrically connected by the flexible wiring which makes conductive member arranged on insulating member the point acting as intermediary, for example, a wire. For this reason, through the above-mentioned conductive member, as compared with the case where it connects electrically, the wiring concerned bends between both power semiconductor devices in flexible wiring, or a lappet can be pressed down directly. Consequently, the short circuit by the lappet of wiring can be prevented.
[0148] (9) According to invention concerning a claim 9, direct attachment of the 1st power semiconductor device is carried out on the electrode of a capacitor. For this reason, both can form a power module into small lightweight rather than the conventional power module formed separately. Moreover, not only generation of heat of the 1st power semiconductor device but the temperature rise of a capacitor can be suppressed by heat dissipation operation of the heat sink concerned by using the electrode of a capacitor as a heat sink.
[0149] Furthermore, since direct attachment of the 1st power semiconductor device is carried out on the electrode of a capacitor, it can shorten sharply rather than the conventional power module above-mentioned [the electrical installation between both]. Thereby, a circuit inductance can be reduced. Therefore, the jumping voltage (overshoot) produced at the time of the switching operation of the 1st power semiconductor device can be reduced, consequently pressure-proofing and loss of the 1st of a power semiconductor device can be reduced. moreover, a wire length -- short -- a bird clapper -- originating -- electromagnetism -- generating of a noise can be reduced
[0150] therefore, small -- it is lightweight and a reliable power module can be offered
[0151] (10) According to invention concerning a claim 10, the refrigeration capacity of a power module can be further improved by pouring a refrigerant to the passage which the electrode of a capacitor has.
[0152] (11) According to invention concerning a claim 11, the 2nd power semiconductor device is arranged on the electrode of a capacitor through the insulating substrate. For this reason, on the electrode of a capacitor, the power semiconductor device from which potential differs can be arranged, and a circuit can be constituted.
[0153] (12) According to invention concerning a claim 12, a reliable power converter can be offered.
[0154] (13) According to invention concerning a claim 13, two or more arms of a power converter enclose a coaxial line, and are arranged by abbreviation regular intervals on the concentric circle. For this reason, since wiring between the 1st electrode and the 2nd electrode, and each arm can be formed similarly, while being able to make small dispersion in each output taken out from each arm, since change by the side of the 1st voltage can be made small, it can be made strong to a malfunction.
[0155] (14) According to invention concerning a claim 14, two or more heat sinks form the space of the 1 continuation which consists of a crevice and the passage of a heat sink in the space of a case. Since the rate of flow of a refrigerant is made quick and the thing of it can be carried out at this time [case / where a crevice is flowed] in case a refrigerant flows the passage of a heat sink, the high cooling performance of a heat sink can be obtained. On the other hand, in case a refrigerant flows a crevice, pressure loss of a refrigerant can be made smaller than the case where the above-mentioned passage is flowed. That is, it is lower pressure loss, with a higher

cooling performance can be realized.
[0156] (15) If it puts in another way, even if it will be the case where a power semiconductor device is soon arranged on a conductive heat sink, without using an insulating substrate since the refrigerant poured in the passage of a heat sink is insulation according to invention concerning a claim 15, each power semiconductor device can be insulated mutually. For this reason, only the part of an insulating substrate can cut down part mark. Furthermore, since the composition containing a power semiconductor device and a heat sink is an outline EQC, respectively, the manufacturing cost of the whole power module can be reduced. Consequently, a cheap power module can be offered.
[0157] Moreover, it originates in each above-mentioned power semiconductor device being insulated mutually, and each power semiconductor device can be soon arranged on a conductive heat sink. Therefore, the heat dissipation performance of a power module can be improved and a reliable power module can be offered.

[Translation done.]

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TECHNICAL FIELD

[The technical field to which invention belongs] This invention relates mainly to the technology which raises the cooling performance of a power module about a power module.

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PRIOR ART

[Description of the Prior Art] The 1st conventional typical external view of power module 101P is shown in drawing 34 . In power module 101P, copper base board 9P are arranged through heat-conduction grease (not shown) on radiation-fin or heat sink 2P, and insulating-substrate 5P are arranged on base board 9P. Furthermore, freewheeling-diode (it is also only hereafter called diode) 1AP and insulated-gate mold bipolar transistor (referred to also as IGBT below Insulated Gate Bipolar Transistor;) 1BP are arranged on insulating-substrate 5P.
[0003] In conventional power module 101P, copper foil 6P are formed in both the principal planes of insulating-substrate 5P, and copper foil 6P and base board 9P are soldered, and diode 1AP and IGBT1BP are soldered on copper foil 6P. Furthermore, electrode 3P are prepared through insulating-layer 4P on radiation-fin 2P. And predetermined electric connection is made by wire 7P. In addition, the composition containing radiation-fin 2P, diode 1AP, IGBT1BP, etc. is stored in the case (not shown).
[0004] A bus bar or wiring 91P are connected to electrode 3P, and bus bar 91P are pulled out besides the above-mentioned case. The current transformer for current detection or current transformer 92P are attached out of the case bus bar 91P. moreover, the object for direct-current smooth [of a cylindrical shape] -- capacitor 8P are prepared separately from radiation-fin 2P grade out of the case (illustration-ization of the topology is omitted)
[0005] The 2nd conventional typical external view of power module 102P is shown in drawing 35 . Power module 102P do not have above-mentioned base board 9P, but insulating-substrate 5P are arranged on radiation-fin 2P through heat-conduction grease. The structure of others of power module 102P is the same as that of above-mentioned power module 101P.
[0006] The 3rd conventional typical external view of power module 103P is shown in drawing 36 . Power module 103P are the so-called power converter. In power module 103P, all diode 1APs and IGBT1BP(s) are arranged on insulating-substrate 5P. In addition, heat sink 2B[of power module 103P] P has breakthrough 2BHP, and a refrigerant is poured by this breakthrough 2BHP. The structure of others of power module 103P is the same as that of above-mentioned power module 101P fundamentally.

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EFFECT OF THE INVENTION

[Effect of the Invention] (1) According to invention concerning a claim 1, direct attachment of the 1st power semiconductor device and capacitor both is carried out on the heat sink. For this reason, both can form a power module into small lightweight rather than the conventional power module formed separately. Moreover, since not only generation of heat of the 1st power semiconductor device but the temperature rise of a capacitor can be suppressed by thermolysis operation of a heat sink, miniaturization of a capacitor, reduction in an inductance, and reinforcement can be attained.
[0138] Furthermore, since direct attachment of the 1st power semiconductor device and capacitor both is carried out on the heat sink, it can be made shorter than the conventional power module above-mentioned [the length of the wiring which connects between both]. For this reason, a circuit inductance can be reduced. Therefore, the jumping voltage (overshoot) produced at the time of the switching operation of the 1st power semiconductor device can be reduced, consequently pressure-proofing and loss of the 1st of a power semiconductor device can be reduced. moreover, a wire length -- short -- a bird clapper -- originating -- electromagnetism -- generating of a noise can be reduced
[0139] therefore, small -- it is lightweight and a reliable power module can be offered
[0140] (2) According to invention concerning a claim 2, since the 1st power semiconductor device and capacitor are arranged on the front face where heat sinks differ, they can form a power module into small lightweight further as compared with the case where both are stationed on the same front face. Moreover, since interference with thermolysis of the 1st power semiconductor device and thermolysis of a capacitor decreases, thermolysis nature can be improved.
[0141] (3) According to invention concerning a claim 3, the refrigeration capacity of a heat sink can be further improved by pouring a refrigerant to the passage of a heat sink.
[0142] (4) According to invention concerning a claim 4, since a heat sink has conductivity, a heat sink can be used as an electrode. For this reason, part mark, such as wiring on a heat sink, and the formation process of that are reducible, for example.
[0143] Furthermore, the electrode of the 1st power semiconductor device and the electrode of a capacitor have pasted up soon with the heat sink. That is, the 1st power semiconductor device and capacitor are electrically connected through the heat sink. For this reason, electrical installation between two electrodes can be further shortened rather than the case where between two electrodes is connected with wiring of a wire etc. consequently, by further reduction of a circuit inductance, the above-mentioned jumping voltage (overshoot) etc. can be boiled markedly, and can be reduced
[0144] (5) According to invention concerning a claim 5, the 2nd power semiconductor device is arranged on the heat sink through the insulating substrate. For this reason, on a conductive heat sink, the power semiconductor device from which potential differs can be arranged, and a circuit can be constituted.
[0145] (6) According to invention concerning a claim 6, it has further the 2nd power semiconductor device arranged on other heat sinks. For this reason, combination can constitute a circuit for the 1st power semiconductor device and 2nd power semiconductor device easily.

[0146] (7) According to invention concerning a claim 7, the potential of the 1st power semiconductor device and the 2nd power semiconductor device can be changed, without using an insulating substrate, since other conductive heat sinks are insulated from the above-mentioned conductive heat sink and the electrode of a capacitor by insulating member. For this reason, only the part of an insulating substrate can cut down part mark. Furthermore, since the composition containing the 1st power semiconductor device and heat sink and the composition containing the 2nd power semiconductor device and heat sink are profile EQCs, the manufacturing cost of the whole power module can be reduced. Consequently, a cheap power module can be offered.
[0147] (8) According to invention concerning a claim 8, the 1st power semiconductor device and 2nd power semiconductor device are electrically connected by the flexible wiring which makes conductive member arranged on insulating member the point acting as intermediary, for example, a wire. For this reason, through the above-mentioned conductive member, as compared with the case where it connects electrically, the wiring concerned bends between both power semiconductor devices in flexible wiring, or a lappet can be pressed down directly. Consequently, the short circuit by the lappet of wiring can be prevented.
[0148] (9) According to invention concerning a claim 9, direct attachment of the 1st power semiconductor device is carried out on the electrode of a capacitor. For this reason, both can form a power module into small lightweight rather than the conventional power module formed separately. Moreover, not only generation of heat of the 1st power semiconductor device but the temperature rise of a capacitor can be suppressed by thermolysis operation of the heat sink concerned by using the electrode of a capacitor as a heat sink.
[0149] Furthermore, since direct attachment of the 1st power semiconductor device is carried out on the electrode of a capacitor, it can shorten sharply rather than the conventional power module above-mentioned [the electrical installation between both]. Thereby, a circuit inductance can be reduced. Therefore, the jumping voltage (overshoot) produced at the time of the switching operation of the 1st power semiconductor device can be reduced, consequently pressure-proofing and loss of the 1st of a power semiconductor device can be reduced. moreover, a wire length -- short -- a bird clapper -- originating -- electromagnetism -- generating of a noise can be reduced
[0150] therefore, small -- it is lightweight and a reliable power module can be offered
[0151] (10) According to invention concerning a claim 10, the refrigeration capacity of a power module can be further improved by pouring a refrigerant to the passage which the electrode of a capacitor has.
[0152] (11) According to invention concerning a claim 11, the 2nd power semiconductor device is arranged on the electrode of a capacitor through the insulating substrate. For this reason, on the electrode of a capacitor, the power semiconductor device from which potential differs can be arranged, and a circuit can be constituted.
[0153] (12) According to invention concerning a claim 12, a reliable power converter can be offered.
[0154] (13) According to invention concerning a claim 13, two or more arms of a power converter enclose a coaxial line, and are arranged by abbreviation regular intervals on the concentric circle. For this reason, since wiring between the 1st electrode and the 2nd electrode, and each arm can be formed similarly, while being able to make small dispersion in each output taken out from each arm, since change by the side of the 1st voltage can be made small, it can be made strong to a malfunction.
[0155] (14) According to invention concerning a claim 14, two or more heat sinks form the space of the 1 continuation which consists of a crevice and the passage of a heat sink in the space of a case. Since the rate of flow of a refrigerant is made quick and the thing of it can be carried out at this time [case / where a crevice is flowed] in case a refrigerant flows the passage of a heat sink, the high cooling performance of a heat sink can be obtained. On the other hand, in case a refrigerant flows a crevice, pressure loss of a refrigerant can be made smaller than the case where the above-mentioned passage is flowed. That is, it is lower pressure loss, with a higher cooling performance can be realized.

[0156] (15) If it puts in another way, even if it will be the case where a power semiconductor device is soon arranged on a conductive heat sink, without using an insulating substrate since the refrigerant poured in the passage of a heat sink is insulation according to invention concerning a claim 15, each power semiconductor device can be insulated mutually. For this reason, only the part of an insulating substrate can cut down part mark. Furthermore, since the composition containing a power semiconductor device and a heat sink is an outline EQC, respectively, the manufacturing cost of the whole power module can be reduced. Consequently, a cheap power module can be offered.
[0157] Moreover, it originates in each above-mentioned power semiconductor device being insulated mutually, and each power semiconductor device can be soon arranged on a conductive heat sink. Therefore, the heat dissipation performance of a power module can be improved and a reliable power module can be offered.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] The conventional power modules 101P-103P have the following troubles. First, there is a trouble that the reliability over the temperature at the time of operation is low.
[0008] In detail, when coefficient of thermal expansion with heat sink 2AP, 2BP and diode 1AP, and IGBT1BP differs, in an above-mentioned soldering portion, the thermal stress according to the temperature gradient from the congealing point of solder occurs. For this reason, the trouble that a crack occurs and advances is in a soldering portion according to the heat cycle by the repeat of the heat cycle (or temperature cycle) and/or the use, and a halt at the time of use of the power modules 101P-103P (at the time of operation). The crack of such a soldering portion will contract the life of a power module.
[0009] At this time, in order to make above-mentioned thermal stress small, it is possible to thicken solder (for example, 300 micrometers or more). However, by such thickness, the thermal resistance between diode 1AP, etc. and heat sink 2AP and 2BP becomes large, and the separate problem that heat sink 2AP and 2BP must be enlarged is caused.
[0010] Furthermore, by the conventional power modules 101P-103P, if temperature distribution arise in insulating-substrate 5P or base board 9P grade by generation of heat of diode 1AP etc., curvature and a wave will occur in insulating-substrate 5P grade. At this time, when a temperature gradient is large, a crevice is formed between radiation-fin 2P and base board 9P etc. For this reason, between radiation-fin 2P, insulating-substrate 5P, or base board 9P is no longer filled with heat-conduction grease (air entering), and there is a trouble that heat transfer will fall. Moreover, or the crack initiation of an above-mentioned soldering portion is promoted, there is a trouble that a crack advances. Formation of this crevice will reduce the reliability of a power module.
[0011] In order to make it not generate an above-mentioned crevice, the temperature distribution for example, within insulating-substrate 5P grade can be equalized, or it is possible to thicken insulating-substrate 5P grade and to increase rigidity. However, if insulating-substrate 5P grade is thickened, the thermal resistance between insulating-substrate 5P grade, and heat sink 2AP and 2BP will become large, and the separate problem that heat sink 2AP and 2BP must be enlarged also in this case is caused.
[0012] Furthermore, since the property of an element is changed by the temperature rise when diode 1AP and the calorific value of IGBT1BP are large, in order to secure reliability, there is a trouble that the amount of current must be restricted.
[0013] Furthermore, by the conventional power modules 101P-103P, since current transformer 92P and capacitor 8P of a cylindrical shape are separately prepared out of the case of a power module, there is a trouble that the whole module is large-sized. Moreover, the property of current transformer 92P will be enlarged when the current to measure contains many dc components, and according to current transformer 92P, measurement will be performed including the measurement error (about 5%) resulting from the property change by generation of heat.
[0014] Moreover, in power module 103P, the distance of electrode 62P connected to an electrode 61P connected to low voltage side by arrangement position of each power semiconductor device of diode 1A and IGBT1B in power converter with each power

semiconductor device and high potential side differs. For this reason, the inductances of wiring of wire 7P grade will differ for every power semiconductor device, consequently output voltage will vary.
[0015] this invention is made in view of this trouble -- having -- small -- it is lightweight and sets it as the main purpose to offer a reliable power module

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MEANS

[Means for Solving the Problem] (1) The power module concerning invention according to claim 1 is characterized by having a heat sink, the 1st power semiconductor device soon arranged on the aforementioned heat sink, and the capacitor soon arranged on the aforementioned heat sink.
[0017] (2) The power module concerning invention according to claim 2 is a power module according to claim 1, and the aforementioned heat sink has two or more front faces, and it is characterized by arranging the 1st power semiconductor device of the above, and the aforementioned capacitor on the aforementioned front face where the aforementioned heat sinks differ.
[0018] (3) The power module concerning invention according to claim 3 is a power module according to claim 1 or 2, and the aforementioned heat sink is characterized by having the passage of a refrigerant.
[0019] (4) The power module concerning invention according to claim 4 is a power module according to claim 1 to 3, and it is characterized by for the aforementioned heat sink having had conductivity and the electrode of the 1st power semiconductor device of the above and the electrode of the aforementioned capacitor having pasted it up soon with the aforementioned heat sink.
[0020] (5) The power module concerning invention according to claim 5 is a power module according to claim 4, and is characterized by having further the insulating substrate arranged on the aforementioned heat sink, and the 2nd power semiconductor device arranged on the aforementioned heat sink through the aforementioned insulating substrate.
[0021] (6) The power module concerning invention according to claim 6 is characterized by having the 2nd power semiconductor device arranged soon on the heat sink of a power module according to claim 4 and others, and a heat sink besides the above.
[0022] (7) The power module concerning invention according to claim 7 is a power module according to claim 6, the heat sink besides the above had conductivity, the electrode of the 2nd power semiconductor device of the above has pasted it up on the heat sink besides the above soon, and the aforementioned power module is characterized by having further the insulating member which insulates a heat sink besides the above from the aforementioned electrode of the aforementioned heat sink and the aforementioned capacitor.
[0023] (8) The power module concerning invention according to claim 8 is a power module according to claim 7, and is characterized by having further the flexible wiring which connects electrically between the 1st power semiconductor device of the above, and the 2nd power semiconductor device of the above, while connecting with the conductive member arranged on the aforementioned insulating member, and the aforementioned conductive member.
[0024] (9) The power module concerning invention according to claim 9 is characterized by having the 1st power semiconductor device arranged soon on the electrode of a capacitor and the aforementioned capacitor.
[0025] (10) The power module concerning invention according to claim 10 is a power module according to claim 9, and the aforementioned electrode of the aforementioned capacitor is characterized by having the passage of a refrigerant.
[0026] (11) The power module concerning invention according to claim 11 is a power module

according to claim 9, and is characterized by having further the insulating substrate arranged on the aforementioned electrode of the aforementioned capacitor, and the 2nd power semiconductor device arranged on the aforementioned electrode of the aforementioned capacitor through the aforementioned insulating substrate.
[0027] (12) The power module concerning invention according to claim 12 is a claim 5 or a power module given in either 8 or 11, and the 1st power semiconductor device of the above and the 2nd power semiconductor device of the above are characterized by connecting electrically, for the 1st power semiconductor device of the above accomplishing the lower arm of a power converter, and the 2nd power semiconductor device of the above accomplishing the upper arm of the aforementioned power converter.
[0028] (13) The power module concerning invention according to claim 13 The plurality of the arm of the aforementioned power converter which is a power module according to claim 12, and contains an above top arm and the bottom arm of the above, The 2nd electrode which supplies the 2nd voltage to each 2nd power semiconductor device of the above of the 1st electrode which supplies the 1st voltage to each 1st power semiconductor device of the above of each bottom arm of the above, and each above top arm is included. It is characterized by having further the coaxial line projected and prepared from the arrangement side of the 1st power semiconductor device of the above, or the 2nd power semiconductor device of the above, and for two or more aforementioned arms enclosing the aforementioned coaxial line, and being arranged by abbreviation regular intervals on a concentric circle.
[0029] (14) The power module concerning invention according to claim 14 Two or more heat sinks with which each has the passage of a refrigerant, and two or more power semiconductor devices by which each was carried on the aforementioned heat sink, It is characterized by having the case which has the space which can contain two or more aforementioned heat sinks, for two or more aforementioned heat sinks opening a crevice mutually into the aforementioned space of the aforementioned case, arranging them, and forming the space of the 1 continuation which consists of the aforementioned crevice and the aforementioned passage in the aforementioned space of the aforementioned case.
[0030] (15) The power module concerning invention according to claim 15 is a power module according to claim 14, and is characterized by pouring an insulating refrigerant in the aforementioned passage of the aforementioned heat sink.
[0031]
[Embodiments of the Invention] The typical external view of the power module 101 concerning the gestalt 1 of the operation to <gestalt 1 of operation> drawing 1 is shown. As shown in drawing 1 , the power module 101 is equipped with the power semiconductor device (for example, a freewheeling diode and IGBT) 1 formed in the silicon (Si) substrate, heat sink 2A, an electrode 3, an insulating layer 4, and a wire 7. In addition, in order to avoid complicated-ization of a drawing, detailed illustration-ization of a power semiconductor device 1 is omitted.
[0032] Or especially the power semiconductor device 1 is soon arranged on heat sink 2A, it has touched. a power semiconductor device 1 corresponds to both the principal planes of the above-mentioned silicon substrate -- both -- principal plane 1S1 and 1S2 -- having -- **** -- each -- the electrode (not shown) is formed in principal plane 1S1 and 1S2, respectively and the electrode (it is also hereafter called a rear-face electrode) formed in the rear-face 1S2 concerned when one principal plane (it is also hereafter called rear face) 1S2 put in another way -- the surface 2AS top of the plane of heat sink 2A -- for example, it is soldered
[0033] Here, it is ["the power semiconductor device 1 is soon arranged on heat sink 2A", and] the meaning of "without it minds insulating-substrate 5P which the conventional power modules 101P-103P have, and base board 9P (refer to drawing 34)", and the composition in which the charge of a binder for pasting both up between a power semiconductor device 1 and heat sink 2A (for example, above-mentioned solder) exists is included in the above-mentioned gestalt by which "arranging soon" was carried out. In addition, you may use thermally conductive good adhesives, such as an epoxy resin containing conductive powder, such as aluminum and silver, instead of solder as the above-mentioned charge of a binder.
[0034] Heat sink 2A contains material with almost equal silicon and coefficient of thermal

expansion, for example, a (Molybdenum Mo) copper (Cu)-molybdenum (Mo) alloy, a tungsten (W), carbon fiber composite material, etc. Or the aluminum (aluminum) which contained carbon (C) and silicon (Si) (as a material with almost equal silicon and coefficient of thermal expansion) is applied as heat sink 2A. Heat sink 2A has the fin configuration in the opposite side of surface 2AS.

[0035] Furthermore, the insulating layer 4 is arranged on heat sink 2A, and the electrode 3 is arranged on the insulating layer 4. That is, an insulating layer 4 insulates and the electrode 3 is arranged on heat sink 2A. The electrode 3 and the electrode (it is also hereafter called a surface electrode) formed in principal plane (it is also hereafter called front face) 1S1 of another side of a power semiconductor device 1 are electrically connected by the wire 7. In addition, you may connect electrically an electrode 3 and the surface electrode of a power semiconductor device 1 by the pressure welding, the electroconductive glue, etc.

[0036] According to the power module 101, the following effects can be acquired. that is, since the coefficient of thermal expansion of a power semiconductor device 1 and heat sink 2A is almost equal, it differs in the conventional power modules 101P-103P, and it can boil markedly that the crack which originated in the heat cycle at a part for the joint of a power semiconductor device 1 and heat sink 2A (soldering portion) occurs, and can suppress For this reason, it differs in the conventional power modules 101P-103P, there is no need of thickening solder, and thermal resistance between a power semiconductor device 1 and heat sink 2A can be made small. Thereby, a heat sink can be formed into small lightweight.

[0037] Furthermore, since a power semiconductor device 1 and heat sink 2A have touched soon, the temperature gradient between a power semiconductor device 1 and heat sink 2A can be made small. for this reason, the conventional power modules 101P-103P -- differing -- even if -- the inside of rear-face 1S2 of a power semiconductor device 1 -- and/or, even if it is the case where temperature distribution arise in surface 2AS of heat sink 2A, or it generates between rear-face 1S2 and surface 2AS, the thermal stress generated in the charge of a binder between rear-face 1S2 and surface 2AS is small Thereby, the reliability of a power semiconductor device is raised, and according to the power module 101, high reliability can be acquired at a long period of time.

[0038] The typical external view of the power module 102 concerning the gestalt 2 of the operation to <gestalt 2 of operation> drawing 2 is shown. As shown in drawing 2 , the power module 102 is equipped with freewheeling-diode 1A as a power semiconductor device 1 as stated above and IGBT1B, heat sink 2A, an electrode 3, an insulating layer 4, and a wire 7. In addition, it stops to give the same sign to a thing equivalent to a component as stated above, and use the explanation for.

[0039] freewheeling-diode 1A -- previous statement -- each -- it has surface 1AS1 corresponding to surface 1S1 and rear-face 1S2 and rear-face 1AS2, and a surface electrode and a rear-face electrode (not shown) the same -- IGBT1B -- previous statement -- each -- it has surface 1BS1 corresponding to surface 1S1 and rear-face 1S2 and rear-face 1BS2, and a surface electrode and a rear-face electrode (not shown)

[0040] Especially heat sink 2A of the power module 102 consists of the copper-molybdenum alloy of the material which has conductivity, for example, an above-mentioned material, etc. And diode 1A and IGBT1B make rear-face 1AS2 and 1BS2 meet surface 2AS of heat sink 2A, and are soon arranged on heat sink 2A. Diode 1A and IGBT1B are pasted up by the charge of a binder which has conductivity, for example, solder, on heat sink 2A. Thereby, both the rear-faces electrode of diode 1A and IGBT1B is electrically connected through solder and conductive heat sink 2A. On the other hand, the surface electrode of diode 1A, the surface electrode of IGBT1B, and the electrode 3 are electrically connected by the wire 7.

[0041] Thus, by the power module 102, since heat sink 2A has conductivity (i.e., since heat sink 2A works as an electrode), the number of an electrode 3 and an insulating layer 4 can be cut down, and a power module can be formed into small lightweight.

[0042] In addition, heat sink 2A of the power module 102 has lobe 2AT which continues from surface 2AS, and the insulating layer 4 and the electrode 3 have extended also on lobe 2AT. Thereby, the electrode 3 on lobe 2AT of conductive heat sink 2A and lobe 2AT can be used as a

terminal of the power module 102.
[0043] In addition, although the power module 102 is applied to the circuitry from which each rear-face electrode of two or more power semiconductor devices mainly serves as the same potential, two or more power semiconductor devices from which the potential of a rear-face electrode differs can be carried by preparing the insulating substrate (equivalent to conventional insulating-substrate 5P (referring to drawing 34)) which has conductive layers, such as copper foil, between heat sink 2A and a power semiconductor device 1.
[0044] The typical external view of the power module 103 concerning the form 3 of the operation to <form 3 of operation> drawing 3 is shown. As shown in drawing 3 , the power module 103 has the composition with which two power modules 102 were combined and united through insulating member 10. An epoxy resin, injection-molding plastics, etc. are applicable as insulating member 10.
[0045] By the power module 103, it extends to the power module 102 side of another side mutually, and connects with heat sink 2A of the power module 102 of the another side concerned electrically, for example, the electrode 3 of each power module 102 is soldered (lobe 3T reference).
[0046] Since according to the power module 103 two power modules 102 are prepared beforehand and a circuit is constituted combining these, a module can be formed easily. Since the power module 102 by which small lightweight-ization was promoted is used at this time, the power module 103 also turns small lightweight. In addition, you may combine three or more power modules 102.
[0047] In addition, you may connect directly between diode 1A and heat sink 2A with a wire 7 through an electrode 3, for example. In this case, electrode 3 grade is further reducible.
[0048] The typical external view of the power module 104 concerning the form 4 of the operation to <form 4 of operation> drawing 4 is shown. As shown in drawing 4 , the power module 104 is equipped with freewheeling-diode 1A, IGBT1B, conductive heat sink 2B, an electrode 3, an insulating layer 4, and a wire 7.
[0049] Heat sink 2B consists of the same material as above-mentioned conductive heat sink 2A, and has surface 2BS of the plane corresponding to the above-mentioned surface 2AS. And diode 1A, IGBT1B, and the insulating layer 4 are arranged on the surface 2BS concerned.
[0050] Especially heat sink 2B of the power module 104 has two breakthrough (passage of refrigerant) 2BH as passage of a refrigerant. From surface 2BS, each breakthrough 2BH is put in order and prepared in it in drawing 4 at the longitudinal direction, if it puts in an of-the-same-grade remote position in another way. Moreover, each breakthrough 2BH is formed so that the lower part of diode 1A and IGBT1B may be passed. In addition, breakthrough 2BH may be one or three or more.
[0051] By the power module 104, by pouring liquids, such as gases, such as 6 refrigerant, for example, air, and sulfur fluoride (SF6) and carbon dioxide gas, and water, an oil, FURORINA, to breakthrough 2BH, heat sink 2B is followed and diode 1A and IGBT1B are cooled compulsorily. Thereby, refrigeration capacity can be raised sharply. consequently, a limit of the amount of current currently made in order to secure reliability like the conventional power modules 101P-103P -- relief -- or -- it can cancel -- moreover, a heat sink -- therefore, a power module can be formed into small lightweight
[0052] The typical external view of power module 104A concerning the modification 1 of the form 4 of the operation to <modification 1 of form 4 of operation> drawing 5 is shown. As shown in drawing 5 , it had two above-mentioned power modules 104, breakthrough 2BH of heat sink 2B was connected by piping 2BJ, and both the power module 104 has connected power module 104A.
[0053] If it puts in another way when setting (i) both heat sink 2B as this potential at this time, in setting rear-face electrodes, such as diode 1A on both heat sink 2B, as this potential In insulating between both heat sink 2Bs to (ii) reverse at least at one side of piping and a refrigerant using conductive material and matter (it is hereafter called electric conduction connection) If it puts in another way, in insulating comrades, such as diode 1A on both heat sink 2B, it uses insulating material and matter for the both sides of piping and a refrigerant (it is

hereafter called insulating connection).
[0054] If insulating-substrate 5P (and copper foil 6P) (refer to drawing 34) of previous statement are prepared between heat sink 2B, diode 1A, etc. even if it is the case where conductive material and matter are used at least for one side of piping and a refrigerant like the above (iii) (i) at this time, diode 1A etc. can be insulated between both heat sink 2Bs like the above (ii). Conversely, if it says, according to above-mentioned electric conduction connection and above-mentioned insulating connection, it is not necessary to use insulating-substrate 5P grade.
[0055] In addition, three or more power modules 104 may be connected for Piping BJ, and power module 104A may be constituted. In electric conduction connection, at this time, the pump (not shown) for pouring a refrigerant is formed for every group by making into one group two or more power modules 104 set as this potential. On the other hand, what is necessary is just to form one pump to the whole power module 104A in insulating connection.
[0056] The typical external view of power module 104B concerning the modification 2 of the form 4 of the operation to <modification 2 of form 4 of operation> drawing 6 is shown. By power module 104B, as shown in drawing 6 , if two breakthrough 2BH changes and puts the distance from surface 2BS in another way, in drawing 6 , it arranges up and down and is formed.
[0057] Like above-mentioned power module 104A, each breakthrough 2BH of two or more power module 104B may be connected by piping 2BJ, and a circuit may be constituted (refer to drawing 7). At this time, it reaches in upper breakthrough 2BH and lower breakthrough 2BH is connected by piping 2BJ, respectively. By piping so that it may flow, a refrigerant may be turned up after that from upper breakthrough 2BH near diode 1A and IGBT1B and it may flow to lower breakthrough 2BH especially, as compared with the above-mentioned power module 104, the temperature gradient of the refrigerant in each heat sink 2B is absorbed, and more uniform refrigeration capacity is obtained.
[0058] The typical external view of power module 104C concerning the modification 3 of the form 4 of the operation to <modification 3 of form 4 of operation> drawing 8 is shown. As shown in drawing 8 , power module 104C is equipped with the two above-mentioned power modules 104, and both the power module 104 is arranged in contact with surface 2BS of heat sink 2B in the front faces of an opposite side.
[0059] The typical external view of power module 104D concerning the modification 4 of the form 4 of the operation to <modification 4 of form 4 of operation> drawing 9 is shown. As shown in drawing 9 , power module 104D is equipped with the two above-mentioned power modules 104, and both the power module 104 is accumulated up and down through the supporter material 15. this time -- (i) -- if conductive members, such as a metal, are used for at least one supporter material 15 -- both heat sink 2B -- this potential -- it can set up -- (ii) -- if insulating member, such as a resin, is used for all the supporter material 15, between both heat sink 2Bs can be insulated
[0060] The typical external view (a plan and side elevation) of the power module 105 applied to the form 5 of operation at <form 5 of operation> drawing 10 and drawing 11 is shown. In addition, drawing 11 is omitting illustration-ization of a part of component in drawing 11 , in order to avoid complicated-ization of a drawing in the external view at the time of seeing the power module 105 from the direction of the arrow A in drawing 10 . Moreover, typical drawing of longitudinal section of the power module 105 is shown in drawing 12 .
[0061] The power module 105 accomplishes the so-called voltage type power converter of a three phase circuit. In addition, an inverter and a converter are included with a power converter. In a power converter, the upper arm and lower arm which accomplish a pair mutually and form an arm are connected in series through an output terminal for every phase, an upper arm is connected between output terminals a high potential (it corresponds to 2nd voltage) side, and a lower arm is connected between an output terminal and a low voltage (it corresponds to 1st voltage) side (or grounded). That is, the power converter has accomplished the polyphase bridge circuit (here three-phase-circuit bridge circuit) in equal circuit.
[0062] The power module 105 is equipped with heat sink 2C of the cylindrical shape which has circular principal plane (front face) 2CS1 which counters, and 2CS2. Heat sink 2C has

conductivity.
[0063] Three insulating substrates 50U, 50V, and 50W which consist of a ceramic board are arranged on one principal plane 2CS1 of heat sink 2C. Copper foil is formed on both the principal planes of each insulating substrates 50U, 50V, and 50W, and insulating substrates 50U, 50V, and 50W are pasted up on principal plane 2CS1 with solder. At this time, the above-mentioned copper foil which meets heat sink 2C is for performing adhesion between insulating substrates 50U, 50V, and 50W and heat sink 2C good. On the other hand, each copper foil which does not meet heat sink 2C on each insulating substrates 50U and 50V and 50W accomplishes each electrodes 60U, 60V, and 60W which are equivalent to the output terminal of a power converter. For this reason, you may use electrical conducting materials other than copper foil as electrodes 60U, 60V, and 60W.
[0064] Especially the insulating substrates 50U, 50V, and 50W are arranged at abbreviation regular intervals on the periphery of circular principal plane 2CS1, and the periphery of this heart. If it puts in another way, only the distance same from the above-mentioned center on the radiation accomplished and specified leaves the same angle (here 120 degrees) mutually to the center of circular principal plane 2CS1, and insulating substrates 50U, 50V, and 50W are arranged.
[0065] Furthermore, the group of the power semiconductor device which consists of one diode each 1A and IGBT1B adjoins 3 sets and insulating substrates 50U, 50V, and 50W, and is soon arranged on principal plane 2CS1. Each class of an above-mentioned power semiconductor device is arranged at abbreviation regular intervals again at the periphery [of circular principal plane 2CS1], and periphery top of this heart between the arrays of each above-mentioned insulating substrates 50U, 50V, and 50W. Especially each rear-face electrode of this diode 1A and IGBT1B is soon pasted up on principal plane 2CS1 with solder. On the other hand, each surface electrode of diode 1A and IGBT1B is electrically connected to Electrodes 60U, 60V, and 60W by the wire 7. Thus, each class of 3 sets of diode 1A and IGBT1B by which direct attachment is carried out on heat sink 2C constitutes the lower arm of a power converter.
[0066] Furthermore, the insulating substrate 5 which consists, for example of a ceramic board approaches insulating substrates 50U, 50V, and 50W, and is arranged on principal plane 2CS1. Each insulating substrate 5 is arranged at abbreviation regular intervals again at the periphery [of circular principal plane 2CS1], and periphery top of this heart between the arrays of each above-mentioned insulating substrates 50U, 50V, and 50W. Copper foil is formed on both the principal planes of each insulating substrate 5, and each insulating substrate 5 is pasted up on principal plane 2CS1 with solder. The copper foil of the side which does not meet heat sink 2C accomplishes a conductive layer 6.
[0067] Diode 1A and IGBT1B are arranged on the conductive layer 6 of each insulating substrate 5. Diode 1A and IGBT1B made each rear-face electrode meet a conductive layer 6, for example, are pasted up with solder. Moreover, the adjoining conductive layer 6 and Electrodes 60U, 60V, and 60W are connected by the wire 7. 3 sets of diode 1A arranged on heat sink 2C through the insulating substrate 5, and IGBT1B -- each constitutes the upper arm of a power converter
[0068] According to the starting arrangement, such as diode 1A, three arms (it consists of an upper arm and a lower arm) which the power module 105 has enclose the circular center (an electrode 61 is arranged like the after-mentioned) concerned of circular principal plane 2CS1 of heat sink 2C, and are arranged by abbreviation regular intervals on the concentric circle.
[0069] And insulating-substrate 50C which consists for example, of a ceramic board near [concerned / circular] a center on circular principal plane 2CS1 is arranged. On both the principal planes of insulating-substrate 50C, copper foil is formed, for example, and insulating-substrate 50C is pasted up on principal plane 2CS1 with solder. The copper foil which does not meet heat sink 2C accomplishes conductive-layer 60C. Each surface electrode of diode 1A on an insulating substrate 5 and IGBT1B is electrically connected with conductive-layer 60C by the wire 7. In addition, configurations, such as insulating-substrate 50C and conductive-layer 60U, are not restricted to the configuration illustrated by drawing 10 etc.
[0070] Especially, it pierced through insulating-substrate 50C from the abbreviation center of circular principal plane 2CS1 which is installation sides, such as diode 1A, for example, the

cylindrical electrode 61 is extended (refer to drawing 12). The electrode 61 is electrically connected with heat sink 2C. Moreover, it connects with conductive-layer 60C electrically, and the electrode 62 is arranged. An electrode 62 consists of a tubed electrode and the electrode 61 is inserted in the tubed interior. Insulating member 11 is arranged between an electrode 61 and 62, and two electrodes 61 and 62 are insulated. Electrodes 61 and 62 accomplish the so-called coaxial line. In addition, by the power module 105, an electrode 62 is [an electrode 61] equivalent to "the 2nd electrode" in "the 1st electrode."

[0071] By such composition, the power module 105 has accomplished the power converter which has five electrodes 60U, 60V, 60W, 61, and 62.

[0072] Here, the ** type view for explaining to drawing 13 breakthrough 2CH which heat sink 2C has is shown. In addition, drawing 13 is a drawing equivalent to drawing 10 , and in order to avoid complicated-ization of a drawing, illustration-ization of the insulating-substrate 5 grade in drawing 10 is omitted. As shown in drawing 13 , three breakthrough 2CH(s) of the shape of an abbreviation ring of the periphery of principal plane 2CS1 and this heart are formed in heat sink 2C (various dashed lines show each). each -- the power module 105 is cooled by pouring a refrigerant to breakthrough 2CH Although the number of breakthrough 2CH is not restricted to three, it is desirable to prepare breakthrough 2CH under diode 1A which is a heating element, and the IGBT1B. Moreover, you may prepare breakthrough 2CH for example, the shape not of a ring but in the shape of a swirl. Moreover, you may prepare breakthrough 2CH in piles up and down between principal plane 2CS1 and 2CS2 like power module 104B (refer to drawing 6).

[0073] According to the power module 105, as mentioned above, three arms of a power converter enclose the above-mentioned coaxial line, and are arranged by abbreviation regular intervals on the concentric circle. For this reason, since wiring between electrodes 61 and 62 and each arm can be formed similarly, while being able to make small dispersion in each output taken out from each arm, since change by the side of low voltage can be made small, it can be made strong to a malfunction. Consequently, a reliable power converter can be offered.

[0074] Although all diode 1A etc. has been arranged on principal plane 2CS1 of heat sink 2C by the <modification 1 of the form 5 of operation>, in addition the power module 105, you may arrange the part on principal plane 2CS2 of another side of sheet sink 2C. For example, the component arranged on three insulating substrates 5 and it may be arranged on principal plane 2CS2, and predetermined wiring may be performed.

[0075] The typical external view of the power module 111 concerning the form 6 of the operation to <form 6 of operation> drawing 14 is shown. As shown in drawing 14 , by the power module 111, the capacitor or capacitor 20 for diode 1A, IGBT1B, and direct-current smooth is soon arranged on surface 2BS of conductive heat sink 2B of the previous statement which has breakthrough 2BH. In addition, diode 1A and IGBT1B hit "the 1st power semiconductor device", respectively.

[0076] Diode 1A has both the principal planes (surface 1AS1 and rear-face 1AS2) corresponding to both the principal planes of a silicon substrate like previous statement, a surface electrode is formed in surface 1AS1, and the rear-face electrode is formed in rear-face 1AS2 again. A surface electrode is formed in surface 1BS1, and the rear-face electrode is formed [in / IGBT1B / similarly] in rear-face 1BS2 again. in order [in addition,] to avoid complicated-ization of a drawing -- drawing 14 -- diode 1A and IGBT1B -- detailed illustration-ization of each surface electrode and a rear-face electrode is omitted

[0077] Especially, it differs in capacitor 8P of the conventional cylindrical shape, and a capacitor 20 consists of the capacitor of a monotonous form which has two principal plane 20S1 which counters, and 20S2. And the electrode (it does not illustrate but is also called; rear-face electrode) is formed in one principal plane (it is also hereafter called rear face) 20S2 of a monotonous form, and the electrode (it does not illustrate but is also called; surface electrode) is formed in principal plane (it is also hereafter called front face) 20S1 of another side.

[0078] Heat sink 2B has pasted up diode 1A, IGBT1B, and each rear-face electrode of a capacitor 20 on heat sink 2C with solder. Thereby, each rear-face electrodes are electrically connected through conductive heat sink 2B. On the other hand, diode 1A, IGBT1B, and each surface electrodes (heat sink 2B is not met) of a capacitor 20 are connected by the wire 7. In

addition, you may connect between each surface electrode electrically by the pressure welding, the electroconductive glue, etc.
[0079] According to the power module 111, the following effects can be acquired. first, small -- it is lightweight and the reliable power module 111 can be offered
[0080] In detail, direct attachment of diode 1A, IGBT1B, and the capacitor 20 is carried out on heat sink 2C. For this reason, these can miniaturize a power module rather than the conventional power modules 101P-103P formed separately. Moreover, since not only generation of heat of diode 1A and IGBT1B but the temperature rise of a capacitor 20 can be suppressed by heat dissipation operation of heat sink 2C, miniaturization of a capacitor 20, reduction in an inductance, and reinforcement can be attained.
[0081] Furthermore, since direct attachment of diode 1A, IGBT1B, and the capacitor 20 is carried out on heat sink 2C, the length of the wiring which connects between diode 1A and IGBT1B, and capacitors 20 can be made shorter than the conventional power modules 101P-103P. Since especially heat sink 2C has conductivity, as for diode 1A, IGBT1B, and the capacitor 20, heat sink 2C is electrically connected with the shortest path. For this reason, a circuit inductance can be reduced rather than the conventional power modules 101P-103P. Therefore, the jumping voltage (overshoot) produced at the time of the switching operation of diode 1A and IGBT1B can be reduced, consequently pressure-proofing and loss of diode 1A and IGBT1B can be reduced. moreover, a wire length -- short -- a bird clapper -- originating -- electromagnetism -- generating of a noise can be reduced
[0082] Moreover, according to the power module 111, since heat sink 2C has conductivity, the heat sink 2C concerned can be used as an electrode. for this reason -- for example, part mark, such as wiring required in the case of an insulating heat sink, and the formation process of that are reducible
[0083] In addition, the refrigeration capacity of heat sink 2B can be improved by pouring a refrigerant to breakthrough 2BH of heat sink 2B.
[0084] Even if it applies conductive heat sink 2A which has fin structure like power module 111A which is <the modification 1 of the form 6 of operation>, and which changes into heat sink 2B and is shown in drawing 15 , an above-mentioned effect can be acquired.
[0085] You may arrange the <modification 2 of the form 6 of operation> and a capacitor 20, diode 1A, and IGBT1B on the front face on which heat sink 2Bs differ. Specifically, like power module 111B shown in drawing 16 , while arranging diode 1A and IGBT1B on surface 2BS of heat sink 2B, you may arrange a capacitor 20 on other surface (side) 2Bs S3 which cross the above-mentioned surface 2BS. Moreover, you may arrange on the above-mentioned surface 2BS and surface 2B S2 which counters. Such composition can be applied when using heat sink 2A.
[0086] According to power module 111B, as compared with the above-mentioned power module 111, a power module can be further formed into small lightweight. Moreover, since interference with heat dissipation of diode 1A and IGBT1B and heat dissipation of a capacitor 20 decreases, heat dissipation nature can be improved.
[0087] The typical external view of the power module 112 concerning the form 7 of the operation to <form 7 of operation> drawing 17 is shown. The power module 112 is changed into a capacitor 20 (refer to drawing 14), and is equipped with the dielectric 33 for capacitors, and the electrode 31 for capacitors so that it may understand, if drawing 17 is compared with drawing 14 as stated above. In detail, the dielectric 33 for capacitors is put by conductive heat sink 2B and the conductive electrode 31 for capacitors, and the capacitor 30 of a monotonous form which is with heat sink 2B, the dielectric 33 for capacitors, and the electrode 31 for capacitors, with is equivalent to the above-mentioned capacitor 20 is constituted. Other composition is the same as that of the power module 111.
[0088] In the electrode 31 for capacitors, at this time, heat sink 2B is equivalent to this rear-face electrode in the surface electrode of a capacitor 20. For this reason, by the power module 112, if diode 1A and IGBT1B are arranged on the rear-face electrode of a capacitor 30, it can catch.
[0089] According to the power module 112, the same effect as the above-mentioned power module 111 is acquired.

[0090] You may apply conductive heat sink 2A which has fin structure like power module 112A which is <the modification 1 of the form 7 of operation>, and which changes into heat sink 2B and is shown in drawing 18 .
[0091] The typical external view of power module 112B concerning the modification 2 of the gestalt 7 of the operation to <modification 2 of gestalt 7 of operation> drawing 19 is shown. In power module 112B, the dielectric 32 for capacitors and the electrode 31 for capacitors are arranged like power module 111B (refer to drawing 16) on surface 2B S2 of a different heat sink 2B from surface 2BS, and surface 2B S3. Such composition can be applied when using heat sink 2A. According to power module 112B, the same effect as above-mentioned power module 111B is acquired.
[0092] The typical external view of power module 111C concerning the gestalt 8 of the operation to <gestalt 8 of operation> drawing 20 is shown. Power module 111C accomplishes the so-called voltage type power converter of a three phase circuit.
[0093] In power module 111C, a capacitor 20 makes the rear-face 20S2 meet above-mentioned surface 2B S2 of heat sink 2B, and is soon arranged on heat sink 2B.
[0094] Power module 11C is equipped with three arms of a power converter. Both one diode each 1A and IGBT1B that accomplish the lower arm of each arm make a rear-face electrode meet heat sink 2B, and are soon arranged on surface 2BS of heat sink 2B. Moreover, each surface electrode of diode 1A of each lower arm and IGBT1B is electrically connected to the electrodes 60U, 60V, and 60W which accomplish the output terminal of a power converter, respectively by the wire 7. In addition, each electrodes 60U, 60V, and 60W are arranged on surface 2BS of heat sink 2B through each insulating substrates (or each insulating layer) 50U, 50V, and 50W.
[0095] On the other hand, one diode each 1A and IGBT1B (each hits the 2nd power semiconductor device) which accomplish the upper arm of each arm are arranged on surface 2BS of heat sink 2B through the insulating substrate 5. At this time, the rear-face electrode of diode 1A of an upper arm and IGBT1B is electrically connected with the conductive layer 6 on an insulating substrate 5. Each conductive layer 6 is electrically connected to the electrodes 60U, 60V, and 60W for each arms by the wire 7. Each surface electrode of diode 1A which accomplishes an upper arm, and IGBT1B is electrically connected to the electrode 61 common to all arms by the wire 7.
[0096] An electrode 61 extends even from surface 2B[of heat sink 2B] S to surface 20S1 of a capacitor 20, and is electrically connected to the surface electrode of a capacitor 20. In addition, the electrode 61 is insulated with portions other than the surface electrode of a capacitor 20, and heat sink 2B by the insulating layer 50.
[0097] In addition, in power module 111C, heat sink 2B is equivalent to the "1st electrode" connected to a low voltage side in the "2nd electrode" by which an electrode 61 is connected to a high potential side.
[0098] According to power module 111C, diode 1A and IGBT1B of an upper arm are arranged on heat sink 2B through the insulating substrate 5. For this reason, on conductive heat sink 2B, diode 1A and IGBT1B from which the potential of a rear-face electrode differs can be made intermingled, and a circuit can be formed.
[0099] The typical external view of power module 112C concerning the modification 1 of the gestalt 8 of the operation to <modification 1 of gestalt 8 of operation> drawing 21 is shown. Power module 112C accomplishes the so-called voltage type power converter of a three phase circuit like above-mentioned power module 111C.
[0100] Power module 112C is changed into the capacitor 20 of power module 111C, and is equipped with the electrode 31 for capacitors, and the dielectric 33 for capacitors so that it may understand, if drawing 21 is compared with drawing 20 as stated above. In detail, the dielectric 33 for capacitors meets surface 2B S2 of heat sink 2B, is arranged, and is inserted by heat sink 2B and the electrode 31 for capacitors. Thereby, it is with heat sink 2B, the dielectric 33 for capacitors, and the electrode 31 for capacitors, with the capacitor 30 of an above-mentioned monotonous form is constituted. Other composition is the same as that of power module 111C.
[0101] According to power module 112C, it will be caught if diode 1A and IGBT1B are arranged

on one electrode of a capacitor 30, and the same effect as the power module 112 can be acquired. Moreover, diode 1A and IGBT1B from which the potential of a rear-face electrode differs by the insulating substrate 5 can be made intermingled on the electrode of a capacitor 30 like the above-mentioned power module 111C.
[0102] The typical external view of the power module 113 concerning <gestalt 9 of operation> drawing 22 and the gestalt 9 of the operation to drawing 23 is shown. Drawing 23 is equivalent to the external view (side elevation) at the time of seeing the power module 113 from the direction of the arrow A in drawing 22 . In addition, in order to avoid complicated-ization of a drawing, in drawing 23 , diode 1A, IGBT1B, and illustration-ization of a wire 7 are omitted. The power module 113 accomplishes the so-called voltage type power converter of a three phase circuit like above-mentioned power module 111C.
[0103] By the power module 113, all diode 1A and IGBT1B of a lower arm of a power converter are soon arranged on surface 2BS of one heat sink 2B for lower arms so that it may understand, if drawing 22 is compared with drawing 20 as stated above. And heat sink 2B and a capacitor 20 make surface 2B S2 and rear-face 20S2 meet, and are arranged, and heat sink 2B and the rear-face electrode of a capacitor 20 have touched electrically.
[0104] on the other hand, diode 1A and IGBT1B of each up arm of a power converter are soon arranged on heat sink (others -- heat sink) 2B which has the conductivity for each up arms, and are electrically connected with the electrode 61 like power module 111C (refer to drawing 20) insulating connection of the three heat sink 2Bs for each up arms is carried out mutually -- **** (illustration-ization of piping 2BJ is omitted in drawing 22) -- insulating member 10 insulates with heat sink 2B for lower arms, and the rear-face electrode of a capacitor 20 In addition, it is insulating member 10, with four heat sink 2Bs and capacitors 20 have joined together in one.
[0105] Heat sink 2B for each up arms is electrically connected by the wire 7 with Electrodes 60U, 60V, and 60W and the wire (flexible wiring) 7 for each arms. Especially the wire 7 concerned has connected the upper arm and the lower arm electrically by making into the point acting as intermediary or a point [course] the portion (conductive member) arranged on insulating member 10 among Electrodes 60U, 60V, and 60W.
[0106] As mentioned above, by the power module 113, it is insulating member 10, with four heat sink 2Bs are insulated mutually. For this reason, the potential of the rear-face electrode of diode 1A for upper arms and IGBT1B and this rear-face electrode for lower arms can be changed, without using an insulating substrate 5 unlike power module 111C (referring to drawing 20) as stated above. For this reason, only the part of an insulating substrate 5 can cut down part mark.
[0107] Furthermore, by the power module 1113, since both the composition of an upper arm and a lower arm is outline EQCs, the manufacturing cost of the whole power module can be reduced. Consequently, the cheap power module 113 can be offered.
[0108] Moreover, the wire 7 which connects an upper arm and a lower arm as mentioned above is connected to the portion (conductive member) arranged on insulating member 10 among Electrodes 60U, 60V, and 60W. For this reason, as compared with the case where between an upper arm and lower arms is directly connected through the above-mentioned conductive member, the wiring concerned bends or a lappet can be pressed down. Consequently, the short circuit by the lappet of wiring can be prevented.
[0109] The typical external view (side elevation) and typical drawing of longitudinal section of power module 111D concerning <form 10 of operation> drawing 24 and the form 10 of the operation to drawing 25 are shown. Since power module 111D has the composition which formed the capacitor 20 in the power module 105 as stated above fundamentally so that it may understand, if drawing 24 is compared with drawing 11 as stated above, it stops to use explanation as stated above for about the same composition as the power module 105, and explanation is advanced focusing on the feature portion of power module 111D. In addition, in drawing 24 , illustration-ization of a part of component is omitted like drawing 11 .
[0110] In addition, three lower arms of a power converter are constituted from diode 1A and IGBT1B by which direct attachment is carried out by heat sink 2C, respectively, and three upper arms of a power converter consist of diode 1A and IGBT1B which are arranged on heat sink 2C

through the insulating substrate 5, respectively.
[0111] As for power module 111D, the capacitor 20 is soon arranged on circular principal plane 2CS2 of conductive heat sink 2C. At this time, a capacitor 20 makes the rear-face 20S2 meet heat sink 2C, and is arranged, and the rear-face electrode 20E2 (refer to drawing 25) of a capacitor 20 and heat sink 2C are connected electrically.
[0112] In power module 111D, the topologies of electrodes 61 and 62 differ especially in the power module 105 as stated above. In detail, as shown in drawing 25 , the cylindrical electrode 61 pierces through heat sink 2C and a capacitor 20 (except for a surface electrode 20E1), extends, and is electrically connected with the surface electrode 20E1 of a capacitor 20. At this time, insulating member 11 is also elongated with the electrode 61, and the electrode 61 is insulated from heat sink 2C and the capacitor 20 (except for a surface electrode 20E2). On the other hand, the tubed electrode 62 pierces through insulating-substrate 50C, is arranged, and is electrically connected with heat sink 2C.
[0113] In power module 111D, an electrode 62 is equivalent to the "1st electrode" connected to a low voltage side in the "2nd electrode" by which an electrode 61 is connected to the high potential side of a power converter.
[0114] While according to power module 111D originating in arrangement of three arms which enclose a coaxial line like the power module 105 as stated above and being able to offer a reliable power converter, a lightweight power converter smaller than conventional power module 103P can be offered.
[0115] The typical external view and typical drawing of longitudinal section of power module 112D concerning the modification 1 of <modification 1 of form 10 of operation> drawing 26 and the form 10 of the operation to drawing 27 are shown. Power module 112D accomplishes the so-called voltage type power converter of a three phase circuit like above-mentioned power module 111D.
[0116] Power module 112D is changed into the capacitor 20 of power module 111D, and is equipped with the electrode 31 for capacitors, and the dielectric 33 for capacitors so that it may understand, if drawing 26 is compared with drawing 24 as stated above. In detail, the dielectric 33 for capacitors meets principal plane 2CS2 of heat sink 2C, is arranged, and is inserted by heat sink 2B and the electrode 31 for capacitors. Thereby, it is with heat sink 2B, the dielectric 33 for capacitors, and the electrode 31 for capacitors, with the capacitor 30 of an above-mentioned monotonous form is constituted. And like power module 111D, the cylindrical electrode 61 of power module 112D pierces through heat sink 2C and the dielectric 33 for capacitors, extends, and is electrically connected with the electrode 31 for capacitors. Other composition is the same as that of power module 111D. For this reason, the same effect as power module 111D can be acquired.
[0117] Moreover, in power module 112D, it will be caught if diode 1A and IGBT1B are arranged on the rear-face electrode of a capacitor 30, and the same effect as the power module 112 can be acquired.
[0118] The ** type view of power module 111E concerning the form 11 of the operation to <form 11 of operation> drawing 28 - drawing 30 is shown. In addition, since it is based on above-mentioned power module 111D, and in order that power module 111E may avoid complicated-ization of a drawing, it omits illustration-ization of some wires 7 in drawing 28 , and is omitting illustration-ization of Electrodes 60U and 60V and 60W grade by drawing 29 and drawing 30 again.
[0119] To all of diode 1A and IGBT1B being arranged on one principal plane 2CS1 of heat sink 2C, by power module 111E, diode 1A and IGBT1B distribute to principal plane 2CS1 of heat sink 2C, and surface 20S1 of a capacitor 20, and are arranged at above-mentioned module 111D.
[0120] Diode 1A and IGBT1B which accomplish the lower arm of a power converter in detail on principal plane 2CS1 of heat sink 2C which has conductivity are arranged soon (refer to drawing 29). And the surface electrodes of concerned diode 1A and IGBT1B are connected. on the other hand, the insulating substrate 5 is arranged on surface 20S1 of a capacitor 20 (detailed -- a surface electrode top), and diode 1A and IGBT1B which accomplish the upper arm of a power converter on the conductive layer 6 of an insulating substrate 5 are arranged (refer to drawing

30) The surface electrode of diode 1A on an insulating substrate 5 and IGBT1B is connected to heat sink 2C.
[0121] Furthermore, the rear-face electrode of IGBT1B of an upper arm, the conductive layer 6 through which it flows, and the surface electrode of IGBT1B of a lower arm are connected, and the arm of a power converter is accomplished (refer to wiring 7B). The above-mentioned node in three arms accomplishes Electrodes 60U, 60V, and 60W. The same effect as power module 111D is acquired by power module 111E.
[0122] In addition, in power module 111E, heat sink 2C is connected to a low voltage side, and the surface electrode of a capacitor 20 is connected to a high potential side. Although illustration-ization to drawing 28 - drawing 30 is omitted at this time, electric power may be supplied by the coaxial line (refer to drawing 25) which has the same topology as power module 111D, and, in this case, an electrode 61 hits [an electrode 62] in "the 1st electrode" at "the 2nd electrode."
[0123] Moreover, you may change the capacitor 20 of power module 111E into the dielectric 33 for capacitors, and the electrode 31 for capacitors like the relation between above-mentioned power module 111D and power module 112D.
[0124] The typical external view of the power module 201 concerning the form 12 of the operation to <form 12 of operation> drawing 31 is shown. The power module 201 is equipped with the insulating case 202 which has two crevice (space) 202K. Heat sink 2B by which direct attachment of heat sink 2B by which direct attachment of the diode 1A was carried out, and the IGBT1B was carried out into each crevice 202K of a case 202 is arranged in by turns, and is contained by one train. In addition, in drawing 31 , illustration-ization of connection of diode 1A and IGBT1B is omitted.
[0125] Under the present circumstances, in each crevice 202K, each heat sink 2B leaves a crevice 203, it is arranged, and the sense of each heat sink 2B or breakthrough 2BH is set that between each crevice 203 is spatially connected by breakthrough 2BH of heat sink 2B. moreover -- each -- heat sink 2B and the size of crevice 202K are specified so that any crevices other than crevice 203 may not be made between the inside of crevice 202K, and heat sink 2B
[0126] In each crevice 202K, the crevice 203 is established in the ends of the list of heat sink 2B, and the hole connected with each crevice 203 concerned is formed in each case 202. and -- each -- piping 2BJ is connected to the hole of one way each of crevice 202K, respectively, the hole of each another side is mutually connected by piping 2BJ, and crevice 202K comrades are connected
[0127] the insulating lid (not shown) which is a part of case 202 covers a crevice 203 -- having -- getting down -- thereby -- both -- so to speak, crevice 202K accomplish the space of 1 continuation For this reason, by the power module 201, a refrigerant can be slushed from one hole of above-mentioned one [of crevice 202K], and a refrigerant can be poured in both crevice 202K. Since both the case 202 and the above-mentioned lid are insulation at this time, if an insulating refrigerant is used, for example, between each heat sink 2B can be insulated (insulating connection). In addition, liquids, such as gases, such as 6 air, sulfur, etc. fluoride (SF6), and an oil, FURORINA, are mentioned as an insulating refrigerant. Moreover, if a conductive refrigerant is used, for example, conductive heat sink 2Bs can be set as this potential (electric conduction connection). Moreover, insulating heat sink 2B and conductive heat sink 2B are combined, and if a conductive refrigerant is used, electric conduction connection only of the desired conductive heat sink 2B can be carried out.
[0128] Now, diode 1A and/or IGBT1B may be arranged on heat sink 2B through an insulating substrate 5, and even if it is the case where conductive heat sink 2B is used in this case, desired diode 1A and/or desired IGBT1B can be insulated from others. Conversely, if it says, an insulating substrate 5 can be made unnecessary by the conductivity/insulation of heat sink 2B as mentioned above. In addition, you may arrange two or more power semiconductor devices on one heat sink 2B.
[0129] As mentioned above, since each heat sink 2B leaves a crevice 203 and is put in order, a refrigerant passes breakthrough 2BH narrower than a crevice 203 and a crevice 203 by turns. If it puts in another way when a refrigerant passes along breakthrough 2BH at this time, when it

passes along the lower part of diode 1A which is a heating element, and IGBT1B, a refrigerant flows quickly rather than the time of passing along a crevice 203. Thereby, the cooling effect can be increased. On the other hand, since the flow of the refrigerant in the crevice section 203 is later than it in breakthrough 2BH, pressure loss can be suppressed. Therefore, according to the power module 201, it is lower pressure loss, with a higher cooling performance can be realized.
[0130] Moreover, if it puts in another way, even if it will be the case where diode 1A and/or IGBT1B are soon arranged on conductive heat sink 2B, without using an insulating substrate 5 by using an insulating refrigerant as mentioned above, each power semiconductor device can be insulated mutually. For this reason, only the part of an insulating substrate 5 can cut down part mark by using an insulating refrigerant. Furthermore, since each heat sink 2B which carried diode 1A and/or IGBT1B is an outline EQC, respectively, the manufacturing cost and price of the whole power module can be reduced.
[0131] Furthermore, it originates in each above-mentioned power semiconductor device being insulated mutually, and each power semiconductor device can be soon arranged on conductive heat sink 2B. Therefore, the heat dissipation performance of a power module can be improved, consequently reliability can be raised.
[0132] The typical external view of the power module 114 concerning the form 13 of the operation to <form 13 of operation> drawing 32 is shown. As shown in drawing 32 , the power module 114 is further equipped with the shunt resistance 90 for amperometries to the power module 113 shown in drawing 22 as stated above. In detail, the shunt resistance 90 is directly connected to the outgoing end of Electrodes 60U, 60V, and 60W, respectively, and each shunt resistance 90 has accomplished each output terminal of a power converter.
[0133] Since current is measured by shunt resistance by the power module 114, it differs in current transformer 92P used in the conventional power module 101P grade, and a control power source is unnecessary and there is no offset theoretically.
[0134] Moreover, since it connects with the outgoing end of Electrodes 60U, 60V, and 60W directly, as compared with the conventional power module 101 grade by which current transformer 92P are separately prepared out of the case, the shunt resistance 90 can form the whole power module into small lightweight, and can cut down the mark of the parts for current measurement.
[0135] The typical external view of power module 114A concerning the modification 1 of the form 13 of the operation to <modification 1 of form 13 of operation> drawing 33 is shown. Each shunt resistance 90 of power module 114A is formed in the position which meets surface 2BS of heat sink 2B, and is directly connected with each electrodes 60U, 60V, and 60W so that it may understand, if drawing 33 is compared with above-mentioned drawing 32 .
[0136] According to power module 114A, the temperature rise of the shunt resistance 90 can be suppressed by operation of a heat sink 90. For this reason, property change of the shunt resistance resulting from the temperature change can be suppressed sharply, consequently the detection precision of the amount of current can be improved further. Moreover, since the shunt resistance 90 is arranged above heat sink 2B, as compared with the above-mentioned power module 114, it can miniaturize further.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the typical external view of the power module concerning the gestalt 1 of operation.
[Drawing 2] It is the typical external view of the power module concerning the gestalt 2 of operation.
[Drawing 3] It is the typical external view of the power module concerning the gestalt 3 of operation.
[Drawing 4] It is the typical external view of the power module concerning the gestalt 4 of operation.
[Drawing 5] It is the typical external view of the power module concerning the modification 1 of the gestalt 4 of operation.
[Drawing 6] It is the typical external view of the power module concerning the modification 2 of the gestalt 4 of operation.
[Drawing 7] It is the typical external view of the power module concerning the modification 2 of the gestalt 4 of operation.
[Drawing 8] It is the typical external view of the power module concerning the modification 3 of the gestalt 4 of operation.
[Drawing 9] It is the typical external view of the power module concerning the modification 4 of the gestalt 4 of operation.
[Drawing 10] It is the typical external view of the power module concerning the gestalt 5 of operation.
[Drawing 11] It is the typical external view of the power module concerning the gestalt 5 of operation.
[Drawing 12] It is typical drawing of longitudinal section of the power module concerning the gestalt 5 of operation.
[Drawing 13] It is a ** type view for explaining the breakthrough which the power module concerning the gestalt 5 of operation has.
[Drawing 14] It is the typical external view of the power module concerning the gestalt 6 of operation.
[Drawing 15] It is the typical external view of the power module concerning the modification 1 of the gestalt 6 of operation.
[Drawing 16] It is the typical external view of the power module concerning the modification 2 of the gestalt 6 of operation.
[Drawing 17] It is the typical external view of the power module concerning the gestalt 7 of operation.
[Drawing 18] It is the typical external view of the power module concerning the modification 1 of the gestalt 7 of operation.
[Drawing 19] It is the typical external view of the power module concerning the modification 2 of the gestalt 7 of operation.
[Drawing 20] It is the typical external view of the power module concerning the gestalt 8 of operation.

[Drawing 21] It is the typical external view of the power module concerning the modification 1 of the gestalt 8 of operation.
[Drawing 22] It is the typical external view of the power module concerning the gestalt 9 of operation.
[Drawing 23] It is the typical external view of the power module concerning the gestalt 9 of operation.
[Drawing 24] It is the typical external view of the power module concerning the gestalt 10 of operation.
[Drawing 25] It is typical drawing of longitudinal section of the power module concerning the gestalt 10 of operation.
[Drawing 26] It is the typical external view of the power module concerning the modification 1 of the gestalt 10 of operation.
[Drawing 27] It is the typical external view of the power module concerning the modification 1 of the gestalt 10 of operation.
[Drawing 28] It is the ** type view of the power module concerning the gestalt 11 of operation.
[Drawing 29] It is the ** type view of the power module concerning the gestalt 11 of operation.
[Drawing 30] It is the ** type view of the power module concerning the gestalt 11 of operation.
[Drawing 31] It is the typical external view of the power module concerning the gestalt 12 of operation.
[Drawing 32] It is the typical external view of the power module concerning the gestalt 13 of operation.
[Drawing 33] It is the typical external view of the power module concerning the modification 1 of the gestalt 13 of operation.
[Drawing 34] It is the typical external view of the 1st conventional power module.
[Drawing 35] It is the typical external view of the 2nd conventional power module.
[Drawing 36] It is the typical external view of the 3rd conventional power module.
[Description of Notations]
1 Power Semiconductor Device, 1A Freewheeling Diode (Power Semiconductor Device), 1B Insulated-gate type bipolar transistor (power semiconductor device), 2A, 2B, 2C A heat sink, 2AS, 2BS, 2B S2, 2B S3 Front face, 2CS1, 2CS2 Principal plane (front face) and 2BH Breakthrough (passage), 4 An insulating layer, 5, 50C, 50U, 50V, 50W Insulating substrate, 60C A conductive layer, 60U, 60V, 60W Electrode (conductive member), 7 A wire (flexible wiring), 10 20 Insulating member, 30 Capacitor, 20E1, 20E2 An electrode, 31 The electrode for capacitors, 33 The dielectric for capacitors, 50 61 An insulating layer (insulating member), 62 An electrode, 101-105,104A-104D, 111-114,111A-111E, 112A-112D, 114A, a 201 power module, 202 A case, 202K Crevice (space).

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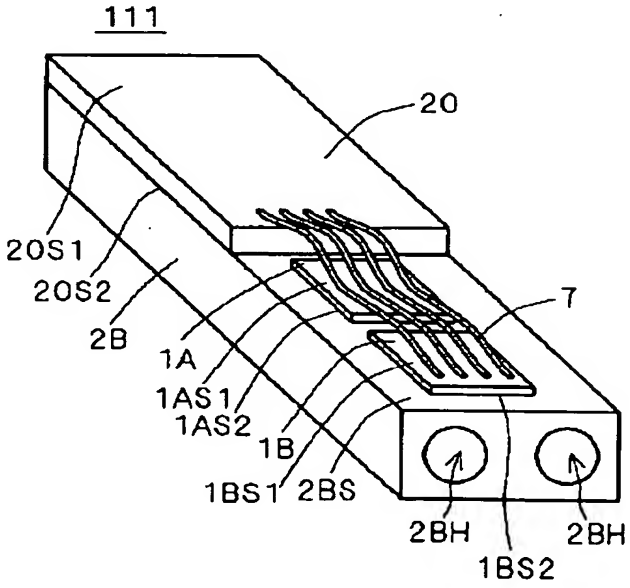
最終頁に続く

(54)【発明の名称】　パワーモジュール

(57)【要約】
【課題】　パワーモジュールの小型化、冷却性能の向上、信頼性の向上を図る。
【解決手段】　パワーモジュール１１１では、貫通孔２ＢＨを有する導電性のヒートシンク２Ｂの表面２ＢＳ上に、フリーホイーリングダイオード１Ａ，ＩＧＢＴ１Ｂ及び直流電流平滑用のキャパシタ２０が直に配置されている。このとき、ダイオード１Ａ，ＩＧＢＴ１Ｂ及びキャパシタ２０の各裏面電極は例えば半田によってヒートシンク２Ｂ上に接着されており、ダイオード１Ａ，ＩＧＢＴ１Ｂ及びキャパシタ２０とヒートシンク２Ｂとが電気的に接続される。他方、ダイオード１Ａ，ＩＧＢＴ１Ｂ及びキャパシタ２０の各表面電極は例えばワイヤ７によって結線されている。ヒートシンク２Ｂの貫通孔２ＢＨには冷媒が流される。



【特許請求の範囲】

【請求項１】　ヒートシンクと、

前記ヒートシンク上に直に配置された第１の電力用半導体素子と、

前記ヒートシンク上に直に配置されたキャパシタとを備えることを特徴とする、パワーモジュール。

【請求項２】　請求項１に記載のパワーモジュールであって、

前記ヒートシンクは複数の表面を有し、

前記第１の電力用半導体素子と前記キャパシタとが前記ヒートシンクの異なる前記表面上に配置されていることを特徴とする、パワーモジュール。

【請求項３】　請求項１又は２に記載のパワーモジュールであって、

前記ヒートシンクは冷媒の流路を有することを特徴とする、パワーモジュール。

【請求項４】　請求項１乃至３のいずれかに記載のパワーモジュールであって、

前記ヒートシンクは導電性を有し、

前記第１の電力用半導体素子の電極及び前記キャパシタの電極が前記ヒートシンクと直に接着されていることを特徴とする、パワーモジュール。

【請求項５】　請求項４に記載のパワーモジュールであって、

前記ヒートシンク上に配置された絶縁基板と、

前記絶縁基板を介して前記ヒートシンク上に配置された第２の電力用半導体素子とを更に備えることを特徴とする、パワーモジュール。

【請求項６】　請求項４に記載のパワーモジュールと、他のヒートシンクと、

前記他のヒートシンク上に直に配置された第２の電力用半導体素子とを備えることを特徴とする、パワーモジュール。

【請求項７】　請求項６に記載のパワーモジュールであって、

前記他のヒートシンクは導電性を有し、

前記他のヒートシンクに、前記第２の電力用半導体素子の電極が直に接着されており、

前記パワーモジュールは、

前記他のヒートシンクを前記ヒートシンク及び前記キャパシタの前記電極から絶縁する絶縁部材を更に備えることを特徴とする、パワーモジュール。

【請求項８】　請求項７に記載のパワーモジュールであって、

前記絶縁部材上に配置された導電部材と、

前記導電部材に接続されると共に、前記第１の電力用半導体素子と前記第２の電力用半導体素子との間を電気的に接続する可撓性の配線とを更に備えることを特徴とする、パワーモジュール。

【請求項９】　キャパシタと、

前記キャパシタの電極上に直に配置された第１の電力用半導体素子とを備えることを特徴とする、パワーモジュール。

【請求項１０】　請求項９に記載のパワーモジュールであって、

前記キャパシタの前記電極は冷媒の流路を有することを特徴とする、パワーモジュール。

【請求項１１】　請求項９に記載のパワーモジュールであって、

前記キャパシタの前記電極上に配置された絶縁基板と、

前記絶縁基板を介して前記キャパシタの前記電極上に配置された第２の電力用半導体素子とを更に備えることを特徴とする、パワーモジュール。

【請求項１２】　請求項５乃至８及び１１の内のいずれかに記載のパワーモジュールであって、

前記第１の電力用半導体素子と前記第２の電力用半導体素子とは電気的に接続されて、前記第１の電力用半導体素子は電力変換器の下アームを成し、前記第２の電力用半導体素子は前記電力変換器の上アームを成すことを特徴とする、パワーモジュール。

【請求項１３】　請求項１２に記載のパワーモジュールであって、

前記上アーム及び前記下アームを含む、前記電力変換器のアームの複数と、

各前記下アームの各前記第１の電力用半導体素子に第１電圧を供給する第１電極及び各前記上アームの各前記第２の電力用半導体素子に第２電圧を供給する第２電極を含み、前記第１の電力用半導体素子又は前記第２の電力用半導体素子の配置面から突出して設けられた同軸線とを更に備え、

複数の前記アームは、前記同軸線を取り囲んで同心円上に略等間隔で配置されていることを特徴とする、パワーモジュール。

【請求項１４】　それぞれが冷媒の流路を有する複数のヒートシンクと、

それぞれが前記ヒートシンク上に搭載された複数の電力用半導体素子と、

前記複数のヒートシンクを収納可能な空間を有する筐体とを備え、

前記複数のヒートシンクは、前記筐体の前記空間内において互いに隙間をあけて配置されて、前記筐体の前記空間内に前記隙間及び前記流路から成る一続きの空間を形成することを特徴とする、パワーモジュール。

【請求項１５】　請求項１４に記載のパワーモジュールであって、

前記ヒートシンクの前記流路に絶　性の冷媒が流されることを特徴とする、パワーモジュール。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明はパワーモジュール

に関するものであり、主として、パワーモジュールの冷却性能を向上させる技術に関する。

【０００２】

【従来の技術】図３４に第１の従来のパワーモジュール１０１Ｐの模式的な外観図を示す。パワーモジュール１０１Ｐでは、放熱フィンないしはヒートシンク２Ｐ上に熱伝導グリス（図示せず）を介して銅ベース板９Ｐが配置されており、ベース板９Ｐ上に絶縁基板５Ｐが配置されている。更に、絶縁基板５Ｐ上にフリーホイーリングダイオード（以下、単にダイオードとも呼ぶ）１ＡＰ及び絶縁ゲート型バイポーラトランジスタ（Insulated Gate Bipolar Transistor；以下、ＩＧＢＴとも呼ぶ）１ＢＰが配置されている。

【０００３】従来のパワーモジュール１０１Ｐでは、絶縁基板５Ｐの両主面には銅箔６Ｐが形成されており、銅箔６Ｐとベース板９Ｐとが半田付けされており、又、ダイオード１ＡＰ及びＩＧＢＴ１ＢＰは銅箔６Ｐ上に半田付けされている。更に、放熱フィン２Ｐ上に絶縁層４Ｐを介して電極３Ｐが設けられている。そして、ワイヤ７Ｐによって所定の電気的結線がなされている。なお、放熱フィン２Ｐ，ダイオード１ＡＰ及びＩＧＢＴ１ＢＰ等を含む構成はケース（図示せず）内に収められている。

【０００４】電極３Ｐにバスバーないしは配線９１Ｐが接続されており、バスバー９１Ｐは上記ケースの外に引き出されている。ケースの外においてバスバー９１Ｐに電流検出用の変流器ないしはカレント・トランスフォーマ９２Ｐが取り付けられている。また、円筒形の直流電流平滑用キャパシタ８Ｐが、ケースの外に放熱フィン２Ｐ等とは別個に設けられている（その接続形態の図示化は省略する）。

【０００５】図３５に第２の従来のパワーモジュール１０２Ｐの模式的な外観図を示す。パワーモジュール１０２Ｐは上述のベース板９Ｐを有さず、絶縁基板５Ｐが熱伝導グリスを介して放熱フィン２Ｐ上に配置されている。パワーモジュール１０２Ｐのその他の構造は上述のパワーモジュール１０１Ｐと同様である。

【０００６】図３６に第３の従来のパワーモジュール１０３Ｐの模式的な外観図を示す。パワーモジュール１０３Ｐは、いわゆる電力変換器である。パワーモジュール１０３Ｐでは、全てのダイオード１ＡＰ及びＩＧＢＴ１ＢＰが絶縁基板５Ｐ上に配置されている。なお、パワーモジュール１０３Ｐのヒートシンク２ＢＰは貫通孔２ＢＨＰを有しており、かかる貫通孔２ＢＨＰに冷媒が流される。パワーモジュール１０３Ｐのその他の構造は基本的には上述のパワーモジュール１０１Ｐと同様である。

【０００７】

【発明が解決しようとする課題】従来のパワーモジュール１０１Ｐ～１０３Ｐは以下の問題点を有している。まず、動作時の温度に対する信頼性が低いという問題点がある。

【０００８】詳細には、ヒートシンク２ＡＰ，２ＢＰとダイオード１ＡＰ及びＩＧＢＴ１ＢＰとの熱膨張率が異なる場合、上述の半田付け部分では半田の凝固点からの温度差に応じた熱応力が発生する。このため、パワーモジュール１０１Ｐ～１０３Ｐの使用時（動作時）における熱サイクル（又は温度サイクル）及び／又は使用と停止との繰り返しによる熱サイクルによって半田付け部分に亀裂が発生・進行するという問題点がある。このような半田付け部分の亀裂はパワーモジュールの寿命を縮めてしまう。

【０００９】このとき、上述の熱応力を小さくするためには例えば半田を厚く（例えば３００μｍ以上）することが考えられる。ところが、そのような厚さではダイオード１ＡＰ等とヒートシンク２ＡＰ，２ＢＰとの間の熱抵抗が大きくなってしまい、ヒートシンク２ＡＰ，２ＢＰを大型化しなければならないという別個の問題が惹起される。

【００１０】更に、従来のパワーモジュール１０１Ｐ～１０３Ｐでは、ダイオード１ＡＰ等の発熱によって絶縁基板５Ｐやベース板９Ｐ等に温度分布が生じると絶縁基板５Ｐ等に反りやうねりが発生する。このとき、温度差が大きい場合には、放熱フィン２Ｐとベース板９Ｐとの間等に隙間が形成される。このため、放熱フィン２Ｐと絶縁基板５Ｐ又はベース板９Ｐとの間が熱伝導グリスで満たされなくなり（空気が入り込み）、熱伝達が低下してしまうという問題点がある。また、上述の半田付け部分の亀裂の発生が助長される又は亀裂が進行するという問題点がある。かかる隙間が形成されると、パワーモジュールの信頼性が低下してしまう。

【００１１】上述の隙間を発生させないようにするためには、例えば絶縁基板５Ｐ等内での温度分布を均一化したり、絶縁基板５Ｐ等を厚くして剛性を増大させることが考えられる。しかしながら、絶縁基板５Ｐ等を厚くすると絶縁基板５Ｐ等とヒートシンク２ＡＰ，２ＢＰとの間の熱抵抗が大きくなってしまい、かかる場合にもヒートシンク２ＡＰ，２ＢＰを大型化しなければならないという別個の問題が惹起される。

【００１２】更に、ダイオード１ＡＰやＩＧＢＴ１ＢＰの発熱量が大きい場合、温度上昇によって素子の特性が変動してしまうので、信頼性を確保するためには電流量を制限しなければならないという問題点がある。

【００１３】更に、従来のパワーモジュール１０１Ｐ～１０３Ｐでは、変流器９２Ｐ及び円筒形のキャパシタ８Ｐをパワーモジュールのケースの外に別個に設けているので、モジュール全体が大型であるという問題点がある。また、変流器９２Ｐの特性は、測定する電流が直流成分を多く含む場合には大型化してしまうし、変流器９２Ｐによれば発熱による特性変動に起因した測定誤差（５％程度）を含んで測定が行われてしまう。

【００１４】また、パワーモジュール１０３Ｐでは、ダ

イオード１Ａ及びＩＧＢＴ１Ｂの各電力用半導体素子の配置位置によって、各電力用半導体素子と、電力変換器において低電位側に接続される電極６１Ｐ及び高電位側に接続される電極６２Ｐとの距離が異なっている。このため、ワイヤ７Ｐ等の配線のインダクタンスが電力用半導体素子毎に異なり、その結果、出力電圧がばらついてしまう。

【００１５】本発明はかかる問題点に鑑みてなされたものであり、小型軽量で信頼性の高いパワーモジュールを提供することを主たる目的とする。

【００１６】

【課題を解決するための手段】（１）請求項１に記載の発明に係るパワーモジュールは、ヒートシンクと、前記ヒートシンク上に直に配置された第１の電力用半導体素子と、前記ヒートシンク上に直に配置されたキャパシタとを備えることを特徴とする。

【００１７】（２）請求項２に記載の発明に係るパワーモジュールは、請求項１に記載のパワーモジュールであって、前記ヒートシンクは複数の表面を有し、前記第１の電力用半導体素子と前記キャパシタとが前記ヒートシンクの異なる前記表面上に配置されていることを特徴とする。

【００１８】（３）請求項３に記載の発明に係るパワーモジュールは、請求項１又は２に記載のパワーモジュールであって、前記ヒートシンクは冷媒の流路を有することを特徴とする。

【００１９】（４）請求項４に記載の発明に係るパワーモジュールは、請求項１乃至３のいずれかに記載のパワーモジュールであって、前記ヒートシンクは導電性を有し、前記第１の電力用半導体素子の電極及び前記キャパシタの電極が前記ヒートシンクと直に接着されていることを特徴とする。

【００２０】（５）請求項５に記載の発明に係るパワーモジュールは、請求項４に記載のパワーモジュールであって、前記ヒートシンク上に配置された絶縁基板と、前記絶縁基板を介して前記ヒートシンク上に配置された第２の電力用半導体素子とを更に備えることを特徴とする。

【００２１】（６）請求項６に記載の発明に係るパワーモジュールは、請求項４に記載のパワーモジュールと、他のヒートシンクと、前記他のヒートシンク上に直に配置された第２の電力用半導体素子とを備えることを特徴とする。

【００２２】（７）請求項７に記載の発明に係るパワーモジュールは、請求項６に記載のパワーモジュールであって、前記他のヒートシンクは導電性を有し、前記他のヒートシンクに、前記第２の電力用半導体素子の電極が直に接着されており、前記パワーモジュールは、前記他のヒートシンクを前記ヒートシンク及び前記キャパシタの前記電極から絶縁する絶縁部材を更に備えることを特

徴とする。

【００２３】（８）請求項８に記載の発明に係るパワーモジュールは、請求項７に記載のパワーモジュールであって、前記絶　部材上に配置された導電部材と、前記導電部材に接続されると共に、前記第１の電力用半導体素子と前記第２の電力用半導体素子との間を電気的に接続する可撓性の配線とを更に備えることを特徴とする。

【００２４】（９）請求項９に記載の発明に係るパワーモジュールは、キャパシタと、前記キャパシタの電極上に直に配置された第１の電力用半導体素子とを備えることを特徴とする。

【００２５】（１０）請求項１０に記載の発明に係るパワーモジュールは、請求項９に記載のパワーモジュールであって、前記キャパシタの前記電極は冷媒の流路を有することを特徴とする。

【００２６】（１１）請求項１１に記載の発明に係るパワーモジュールは、請求項９に記載のパワーモジュールであって、前記キャパシタの前記電極上に配置された絶縁基板と、前記絶縁基板を介して前記キャパシタの前記電極上に配置された第２の電力用半導体素子とを更に備えることを特徴とする。

【００２７】（１２）請求項１２に記載の発明に係るパワーモジュールは、請求項５乃至８及び１１の内のいずれかに記載のパワーモジュールであって、前記第１の電力用半導体素子と前記第２の電力用半導体素子とは電気的に接続されて、前記第１の電力用半導体素子は電力変換器の下アームを成し、前記第２の電力用半導体素子は前記電力変換器の上アームを成すことを特徴とする。

【００２８】（１３）請求項１３に係るパワーモジュールは、請求項１２に記載のパワーモジュールであって、前記上アーム及び前記下アームを含む、前記電力変換器のアームの複数と、各前記下アームの各前記第１の電力用半導体素子に第１電圧を供給する第１電極及び各前記上アームの各前記第２の電力用半導体素子に第２電圧を供給する第２電極を含み、前記第１の電力用半導体素子又は前記第２の電力用半導体素子の配置面から突出して設けられた同軸線とを更に備え、複数の前記アームは、前記同軸線を取り囲んで同心円上に略等間隔で配置されていることを特徴とする。

【００２９】（１４）請求項１４に記載の発明に係るパワーモジュールは、それぞれが冷媒の流路を有する複数のヒートシンクと、それぞれが前記ヒートシンク上に搭載された複数の電力用半導体素子と、前記複数のヒートシンクを収納可能な空間を有する筐体とを備え、前記複数のヒートシンクは、前記筐体の前記空間内において互いに隙間をあけて配置されて、前記筐体の前記空間内に前記隙間及び前記流路から成る一続きの空間を形成することを特徴とする。

【００３０】（１５）請求項１５に記載の発明に係るパワーモジュールは、請求項１４に記載のパワーモジュー

ルであって、前記ヒートシンクの前記流路に絶縁性の冷媒が流されることを特徴とする。

【００３１】

【発明の実施の形態】＜実施の形態１＞図１に実施の形態１に係るパワーモジュール１０１の模式的な外観図を示す。図１に示すように、パワーモジュール１０１は、例えばシリコン（Ｓｉ）基板に形成された電力用半導体素子（例えばフリーホイーリングダイオードやＩＧＢＴ）１と、ヒートシンク２Ａと、電極３と、絶縁層４と、ワイヤ７とを備える。なお、図面の煩雑化を避けるため、電力用半導体素子１の詳細な図示化は省略している。

【００３２】特に、電力用半導体素子１はヒートシンク２Ａ上に直に配置されているないしは接している。電力用半導体素子１は、上記シリコン基板の両主面に対応する両主面１Ｓ１，１Ｓ２を有しており、各主面１Ｓ１，１Ｓ２にそれぞれ電極（図示せず）が形成されている。そして、一方の主面（以下、裏面とも呼ぶ）１Ｓ２が、換言すれば当該裏面１Ｓ２に形成された電極（以下、裏面電極とも呼ぶ）がヒートシンク２Ａの平面状の表面２ＡＳ上に例えば半田付けされている。

【００３３】ここで、「電力用半導体素子１がヒートシンク２Ａ上に直に配置されている」とは、「従来のパワーモジュール１０１Ｐ～１０３Ｐが有する絶縁基板５Ｐやベース板９Ｐ（図３４参照）を介することなく」の意味であり、電力用半導体素子１とヒートシンク２Ａとの間に両者を接着するための接着材料（例えば上述の半田）が存在している構成は上述の「直に配置」された形態に含まれる。なお、上記接着材料として、半田の代わりに、アルミニウムや銀等の導電性粉末を含んだエポキシ樹脂等の熱伝導性の良好な接着剤を用いても構わない。

【００３４】ヒートシンク２Ａはシリコンと熱膨張率がほぼ等しい材料、例えばモリブデン（Ｍｏ），銅（Ｃｕ）－モリブデン（Ｍｏ）合金，タングステン（Ｗ），炭素繊維複合材料等を含む。或いは、ヒートシンク２Ａとして（シリコンと熱膨張率がほぼ等しい材料として）、炭素（Ｃ）やシリコン（Ｓｉ）を含有したアルミニウム（ＡｌＳｉ）等を適用する。ヒートシンク２Ａは表面２ＡＳの反対側にフィン形状を有している。

【００３５】更に、ヒートシンク２Ａ上に絶縁層４が配置されており、絶縁層４上に電極３が配置されている。即ち、電極３は絶縁層４により絶縁されてヒートシンク２Ａ上に配置されている。電極３と、電力用半導体素子１の他方の主面（以下、表面とも呼ぶ）１Ｓ１に形成された電極（以下、表面電極とも呼ぶ）とがワイヤ７によって電気的に結線されている。なお、圧接や導電性接着剤等によって、電極３と電力用半導体素子１の表面電極とを電気的に接続しても構わない。

【００３６】パワーモジュール１０１によれば以下の効

果を得ることができる。即ち、電力用半導体素子１とヒートシンク２Ａとの熱膨張率がほぼ等しいので、従来のパワーモジュール１０１Ｐ～１０３Ｐとは異なり、電力用半導体素子１とヒートシンク２Ａとの接合部分（半田付け部分）に熱サイクルに起因した亀裂が発生するのを格段に抑制することができる。このため、従来のパワーモジュール１０１Ｐ～１０３Ｐとは異なり、半田を厚くする必要が無く、電力用半導体素子１とヒートシンク２Ａとの間の熱抵抗を小さくすることができる。これにより、ヒートシンクを小型軽量化することができる。

【００３７】更に、電力用半導体素子１とヒートシンク２Ａとが直に接しているので、電力用半導体素子１とヒートシンク２Ａとの間の温度差を小さくすることができる。このため、従来のパワーモジュール１０１Ｐ～１０３Ｐとは異なり、たとえ電力用半導体素子１の裏面１Ｓ２内に及び／又はヒートシンク２Ａの表面２ＡＳ内に温度分布が生じた場合であっても、裏面１Ｓ２と表面２ＡＳとの間に発生する或いは裏面１Ｓ２と表面２ＡＳとの間の接着材料に発生する熱応力が小さい。これにより、電力用半導体素子の信頼性を高められ、パワーモジュール１０１によれば高い信頼性を長期に得ることができる。

【００３８】＜実施の形態２＞図２に実施の形態２に係るパワーモジュール１０２の模式的な外観図を示す。図２に示すように、パワーモジュール１０２は、既述の電力用半導体素子１としてのフリーホイーリングダイオード１Ａ及びＩＧＢＴ１Ｂと、ヒートシンク２Ａと、電極３と、絶縁層４と、ワイヤ７とを備える。なお、既述の構成要素と同等のものには同一の符号を付してその説明を援用するに留める。

【００３９】フリーホイーリングダイオード１Ａは、既述の各表面１Ｓ１及び裏面１Ｓ２に対応する表面１ＡＳ１及び裏面１ＡＳ２と、表面電極及び裏面電極（図示せず）とを有する。同様に、ＩＧＢＴ１Ｂも、既述の各表面１Ｓ１及び裏面１Ｓ２に対応する表面１ＢＳ１及び裏面１ＢＳ２と、表面電極及び裏面電極（図示せず）とを有する。

【００４０】特に、パワーモジュール１０２のヒートシンク２Ａは導電性を有する材料、例えば上述の材料の内の銅－モリブデン合金等から成る。そして、ダイオード１Ａ及びＩＧＢＴ１Ｂが、裏面１ＡＳ２，１ＢＳ２をヒートシンク２Ａの表面２ＡＳに対面させて、ヒートシンク２Ａ上に直に配置されている。ダイオード１Ａ及びＩＧＢＴ１Ｂは、導電性を有する接着材料、例えば半田でヒートシンク２Ａ上に接着されている。これにより、ダイオード１Ａ及びＩＧＢＴ１Ｂの両裏面電極は半田及び導電性のヒートシンク２Ａを介して電気的に接続されている。他方、ダイオード１Ａの表面電極とＩＧＢＴ１Ｂの表面電極と電極３とが例えばワイヤ７によって電気的に接続されている。

【００４１】このように、パワーモジュール１０２では、ヒートシンク２Ａが導電性を有するので、即ちヒートシンク２Ａが電極として働くので、電極３及び絶縁層４の個数を削減してパワーモジュールを小型軽量化することができる。

【００４２】なお、パワーモジュール１０２のヒートシンク２Ａは、表面２ＡＳから続く突出部２ＡＴを有しており、絶縁層４及び電極３は突出部２ＡＴ上にも延在している。これにより、導電性のヒートシンク２Ａの突出部２ＡＴと突出部２ＡＴ上の電極３とをパワーモジュール１０２の端子として利用することができる。

【００４３】なお、パワーモジュール１０２は主として複数の電力用半導体素子の各裏面電極が同一電位となる回路構成に適用されるが、ヒートシンク２Ａと電力用半導体素子１との間に、銅箔等の導電層を有する絶縁基板（従来の絶縁基板５Ｐ（図３４参照）に相当）を設けることによって、裏面電極の電位が異なる複数の電力用半導体素子を搭載することができる。

【００４４】＜実施の形態３＞図３に実施の形態３に係るパワーモジュール１０３の模式的な外観図を示す。図３に示すように、パワーモジュール１０３は、２つのパワーモジュール１０２が絶縁部材１０を介して結合され一体化された構成を有する。絶縁部材１０として例えばエポキシ樹脂や射出成形プラスチック等が適用可能である。

【００４５】パワーモジュール１０３では、各パワーモジュール１０２の電極３は、互いに他方のパワーモジュール１０２側へ延在して当該他方のパワーモジュール１０２のヒートシンク２Ａに電気的に接続されている、例えば半田付けされている（突出部３Ｔ参照）。

【００４６】パワーモジュール１０３によれば、２つのパワーモジュール１０２を予め準備しておき、これらを組み合わせて回路を構成するので、モジュールを容易に形成することができる。このとき、小型軽量化が推進されたパワーモジュール１０２を用いるので、パワーモジュール１０３も小型軽量化される。なお、３つ以上のパワーモジュール１０２を組み合わせても構わない。

【００４７】なお、電極３を介することなく、例えばダイオード１Ａとヒートシンク２Ａとの間を直接にワイヤ７で接続しても構わない。かかる場合には、電極３等を更に削減することができる。

【００４８】＜実施の形態４＞図４に実施の形態４に係るパワーモジュール１０４の模式的な外観図を示す。図４に示すように、パワーモジュール１０４は、フリーホイーリングダイオード１Ａと、ＩＧＢＴ１Ｂと、導電性のヒートシンク２Ｂと、電極３と、絶縁層４と、ワイヤ７とを備える。

【００４９】ヒートシンク２Ｂは上述の導電性のヒートシンク２Ａと同様の材料から成り、上記表面２ＡＳに対応する平面状の表面２ＢＳを有する。そして、当該表面

２ＢＳ上にダイオード１Ａ，ＩＧＢＴ１Ｂ及び絶縁層４が配置されている。

【００５０】特に、パワーモジュール１０４のヒートシンク２Ｂは冷媒の流路としての２つの貫通孔（冷媒の流路）２ＢＨを有する。各貫通孔２ＢＨは表面２ＢＳから同程度離れた位置に、換言すれば図４において横方向に並べて設けられている。また、各貫通孔２ＢＨはダイオード１Ａ及びＩＧＢＴ１Ｂの下方を通過するように形成されている。なお、貫通孔２ＢＨは１つ或いは３つ以上であっても構わない。

【００５１】パワーモジュール１０４では、貫通孔２ＢＨに冷媒、例えば空気，六フッ化硫黄（SF_6），炭酸ガス等の気体や、水，油，フロリーナ等の液体を流すことによって、ヒートシンク２Ｂを従ってダイオード１Ａ及びＩＧＢＴ１Ｂを強制的に冷却する。これにより、冷却能力を大幅に向上させることができる。その結果、従来のパワーモジュール１０１Ｐ～１０３Ｐのように信頼性を確保するためになされていた電流量の制限を緩和或いは解除することができるし、又、ヒートシンクを、従ってパワーモジュールを小型軽量化することができる。

【００５２】＜実施の形態４の変形例１＞図５に実施の形態４の変形例１に係るパワーモジュール１０４Ａの模式的な外観図を示す。図５に示すように、パワーモジュール１０４Ａは上述のパワーモジュール１０４を２つ備え、ヒートシンク２Ｂの貫通孔２ＢＨ同士が配管２ＢＪで繋がれて、両パワーモジュール１０４が連結している。

【００５３】このとき、（ｉ）両ヒートシンク２Ｂを同電位に設定する場合、換言すれば両ヒートシンク２Ｂ上のダイオード１Ａ等の裏面電極同士を同電位に設定する場合には、配管と冷媒との少なくとも一方に導電性の材料・物質を用い（以下、導電連結と呼ぶ）、（ｉｉ）逆に、両ヒートシンク２Ｂ間を絶縁する場合には、換言すれば両ヒートシンク２Ｂ上のダイオード１Ａ等同士を絶縁する場合には、配管及び冷媒の双方に絶縁性の材料・物質を用いる（以下、絶縁連結と呼ぶ）。

【００５４】このとき、（ｉｉｉ）上記（ｉ）のように配管と冷媒との少なくとも一方に導電性の材料・物質を用いた場合であっても、ヒートシンク２Ｂとダイオード１Ａ等との間に既述の絶縁基板５Ｐ（及び銅箔６Ｐ）（図３４参照）を設ければ、上記（ｉｉ）と同様に両ヒートシンク２Ｂ間でダイオード１Ａ等を絶縁することができる。逆に言えば、上述の導電連結及び絶縁連結によれば、絶縁基板５Ｐ等を用いる必要がない。

【００５５】なお、３つ以上のパワーモジュール１０４を配管ＢＪで連結してパワーモジュール１０４Ａを構成しても良い。このとき、導電連結の場合、同電位に設定する複数のパワーモジュール１０４を１グループとして、各グループ毎に、冷媒を流すためのポンプ（図示せず）を設ける。他方、絶縁連結の場合、パワーモジュー

ル１０４Ａ全体に対して、１つのポンプを設ければ良い。

【００５６】＜実施の形態４の変形例２＞図６に実施の形態４の変形例２に係るパワーモジュール１０４Ｂの模式的な外観図を示す。図６に示すように、パワーモジュール１０４Ｂでは、２つの貫通孔２ＢＨが表面２ＢＳからの距離を違えて、換言すれば図６において上下に並べて形成されている。

【００５７】上述のパワーモジュール１０４Ａと同様に、複数のパワーモジュール１０４Ｂの各貫通孔２ＢＨ同士を配管２ＢＪで連結して回路を構成しても構わない（図７参照）。このとき、上側の貫通孔２ＢＨ同士を及び下側の貫通孔２ＢＨ同士をそれぞれ配管２ＢＪでつなぐ。特に、ダイオード１Ａ及びＩＧＢＴ１Ｂに近い、上側の貫通孔２ＢＨから冷媒を流入し、その後、折り返して下側の貫通孔２ＢＨに流れるように配管することによって、上記パワーモジュール１０４と比較して、各ヒートシンク２Ｂでの冷媒の温度差が吸収され、より均一な冷却能力が得られる。

【００５８】＜実施の形態４の変形例３＞図８に実施の形態４の変形例３に係るパワーモジュール１０４Ｃの模式的な外観図を示す。図８に示すように、パワーモジュール１０４Ｃは上記パワーモジュール１０４を２つ備え、両パワーモジュール１０４がヒートシンク２Ｂの表面２ＢＳとは反対側の表面同士を接して配置されている。

【００５９】＜実施の形態４の変形例４＞図９に実施の形態４の変形例４に係るパワーモジュール１０４Ｄの模式的な外観図を示す。図９に示すように、パワーモジュール１０４Ｄは上記パワーモジュール１０４を２つ備え、両パワーモジュール１０４が支持部材１５を介して上下に積み重ねられている。このとき、（ｉ）少なくとも１つの支持部材１５に金属等の導電性部材を用いれば両ヒートシンク２Ｂを同電位に設定することができるし、（ｉｉ）全ての支持部材１５に樹脂等の絶縁部材を用いれば両ヒートシンク２Ｂ間を絶縁することができる。

【００６０】＜実施の形態５＞図１０及び図１１に、実施の形態５に係るパワーモジュール１０５の模式的な外観図（上面図及び側面図）を示す。なお、図１１は図１０中の矢印Ａの方向からパワーモジュール１０５を見た場合の外観図にあたり、図面の煩雑化を避けるために図１１では構成要素の一部の図示化を省略している。また、図１２に、パワーモジュール１０５の模式的な縦断面図を示す。

【００６１】パワーモジュール１０５は、いわゆる３相の電圧型電力変換器を成す。なお、電力変換器とはインバータ及びコンバータを含む。電力変換器では、各相毎に、互いに対を成してアームを形成する上アームと下アームとが出力端子を介して直列に接続され、上アームは

高電位（第２電圧に対応する）側と出力端子との間に接続され、下アームは出力端子と低電位（第１電圧に対応する）側との間に接続される（又は接地される）。即ち、電力変換器は、等価回路的には多相ブリッジ回路（ここでは、３相ブリッジ回路）を成している。

【００６２】パワーモジュール１０５は、対向する円形の主面（表面）２ＣＳ１，２ＣＳ２を有する円柱形のヒートシンク２Ｃを備える。ヒートシンク２Ｃは導電性を有する。

【００６３】ヒートシンク２Ｃの一方の主面２ＣＳ１上に例えばセラミック板より成る３つの絶縁基板５０Ｕ，５０Ｖ，５０Ｗが配置されている。各絶縁基板５０Ｕ，５０Ｖ，５０Ｗの両主面上に例えば銅箔が形成されており、絶縁基板５０Ｕ，５０Ｖ，５０Ｗは例えば半田により主面２ＣＳ１上に接着されている。このとき、ヒートシンク２Ｃと対面する上記銅箔は、絶縁基板５０Ｕ，５０Ｖ，５０Ｗとヒートシンク２Ｃとの間の接着を良好に行うためのものである。他方、各絶縁基板５０Ｕ，５０Ｖ，５０Ｗ上の、ヒートシンク２Ｃとは対面しない各銅箔は、電力変換器の出力端子にあたる各電極６０Ｕ，６０Ｖ，６０Ｗを成す。このため、電極６０Ｕ，６０Ｖ，６０Ｗとして銅箔以外の導電材料を用いても構わない。

【００６４】特に、絶縁基板５０Ｕ，５０Ｖ，５０Ｗは、円形の主面２ＣＳ１の円周と同心の円周上に略等間隔に配置されている。換言すれば、円形の主面２ＣＳ１の中心に対して互いに同じ角度（ここでは１２０°）を成して規定される放射線上に上記中心から同じ距離だけ離れて、絶縁基板５０Ｕ，５０Ｖ，５０Ｗが配置されている。

【００６５】更に、各１つのダイオード１Ａ及びＩＧＢＴ１Ｂから成る電力用半導体素子の組が、３組、絶縁基板５０Ｕ，５０Ｖ，５０Ｗに隣接して主面２ＣＳ１上に直に配置されている。上述の電力用半導体素子の各組は、円形の主面２ＣＳ１の円周と同心の円周上に略等間隔に又上記各絶縁基板５０Ｕ，５０Ｖ，５０Ｗの配列間に配置されている。特に、かかるダイオード１Ａ及びＩＧＢＴ１Ｂの各裏面電極は例えば半田により主面２ＣＳ１上に直に接着されている。他方、ダイオード１Ａ及びＩＧＢＴ１Ｂの各表面電極は例えばワイヤ７により電極６０Ｕ，６０Ｖ，６０Ｗに電気的に接続されている。このようにヒートシンク２Ｃ上に直付けされている、３組のダイオード１Ａ及びＩＧＢＴ１Ｂの各組が電力変換器の下アームを構成する。

【００６６】更に、例えばセラミック板より成る絶縁基板５が絶縁基板５０Ｕ，５０Ｖ，５０Ｗに近接して主面２ＣＳ１上に配置されている。各絶縁基板５は、円形の主面２ＣＳ１の円周と同心の円周上に略等間隔に又上記各絶縁基板５０Ｕ，５０Ｖ，５０Ｗの配列間に配置されている。各絶縁基板５の両主面上に例えば銅箔が形成されており、各絶縁基板５は例えば半田により主面２ＣＳ

１に接着されている。ヒートシンク２Ｃと対面しない側の銅箔は導電層６を成す。

【００６７】各絶　基板５の導電層６上にダイオード１Ａ及びＩＧＢＴ１Ｂが配置されている。ダイオード１Ａ及びＩＧＢＴ１Ｂはそれぞれの裏面電極を導電層６と対面させて例えば半田により接着されている。また、隣接する導電層６と電極６０Ｕ，６０Ｖ，６０Ｗとが例えばワイヤ７によって接続されている。絶縁基板５を介してヒートシンク２Ｃ上に配置されている、３組のダイオード１Ａ及びＩＧＢＴ１Ｂそれぞれが電力変換器の上アームを構成する。

【００６８】ダイオード１Ａ等のかかる配置によれば、パワーモジュール１０５が有する３つのアーム（上アーム及び下アームから成る）は、ヒートシンク２Ｃの円形の主面２ＣＳ１の当該円形の中心（後述のように電極６１が配置される）を取り囲んで同心円上に略等間隔で配置されている。

【００６９】そして、円形の主面２ＣＳ１上に、当該円形の中心付近に例えばセラミック板より成る絶縁基板５０Ｃが配置されている。絶縁基板５０Ｃの両主面上には例えば例えば銅箔が形成されており、絶縁基板５０Ｃは例えば半田により主面２ＣＳ１に接着されている。ヒートシンク２Ｃと対面しない銅箔は導電層６０Ｃを成す。絶縁基板５上のダイオード１Ａ及びＩＧＢＴ１Ｂの各表面電極が例えばワイヤ７により導電層６０Ｃと電気的に接続されている。なお、絶縁基板５０Ｃや導電層６０Ｕ等の形状は、図１０等に図示された形状に限られない。

【００７０】特に、ダイオード１Ａ等の設置面である円形の主面２ＣＳ１の略中心から絶縁基板５０Ｃを貫いて例えば棒状の電極６１が伸びている（図１２参照）。電極６１はヒートシンク２Ｃと電気的に接続されている。また、導電層６０Ｃと電気的に接続されて電極６２が配置されている。電極６２は例えば筒状の電極から成り、その筒状の内部に電極６１が挿入されている。電極６１，６２間には絶縁部材１１が配置されており、両電極６１，６２は絶縁されている。電極６１，６２はいわゆる同軸線を成す。なお、パワーモジュール１０５では、電極６１が「第１電極」にあたり、電極６２が「第２電極」にあたる。

【００７１】このような構成により、パワーモジュール１０５は、５つの電極６０Ｕ，６０Ｖ，６０Ｗ，６１，６２を有する電力変換器を成している。

【００７２】ここで、図１３にヒートシンク２Ｃが有する貫通孔２ＣＨを説明するための模式図を示す。なお、図１３は図１０に相当する図面であり、図面の煩雑化を避けるために図１０中の絶縁基板５等の図示化は省略している。図１３に示すように、ヒートシンク２Ｃには、主面２ＣＳ１の円周と同心の略リング状の貫通孔２ＣＨが３つ形成されている（それぞれを各種破線で示す）。各貫通孔２ＣＨに冷媒を流すことにより、パワーモジュール１０５の冷却を行う。貫通孔２ＣＨの個数は３つに限られないが、貫通孔２ＣＨを発熱体であるダイオード１Ａ及びＩＧＢＴ１Ｂの下方に設けることが好ましい。また、貫通孔２ＣＨをリング状でなく例えば渦巻き状に設けても構わない。また、パワーモジュール１０４Ｂ（図６参照）のように、主面２ＣＳ１，２ＣＳ２間に上下に重ねて貫通孔２ＣＨを設けても構わない。

【００７３】パワーモジュール１０５によれば、上述のように電力変換器の３つのアームは上記同軸線を取り囲んで同心円上に略等間隔で配置されている。このため、電極６１，６２と各アームとの間の配線を同様に形成することができるので、各アームから取り出される各出力のばらつきを小さくすることができると共に、低電位側の変動を小さくできるため誤動作に強くすることができる。その結果、信頼性の高い電力変換器を提供することができる。

【００７４】＜実施の形態５の変形例１＞なお、パワーモジュール１０５ではヒートシンク２Ｃの主面２ＣＳ１上にダイオード１Ａ等を全て配置したが、その一部をシートシンク２Ｃの他方の主面２ＣＳ２上に配置しても構わない。例えば、３つの絶縁基板５及びそれの上に配置された構成要素を主面２ＣＳ２上に配置し、所定の配線を行っても構わない。

【００７５】＜実施の形態６＞図１４に実施の形態６に係るパワーモジュール１１１の模式的な外観図を示す。図１４に示すように、パワーモジュール１１１では、貫通孔２ＢＨを有する既述の導電性のヒートシンク２Ｂの表面２ＢＳ上に、ダイオード１Ａ，ＩＧＢＴ１Ｂ及び直流電流平滑用のコンデンサないしはキャパシタ２０が直に配置されている。なお、ダイオード１Ａ及びＩＧＢＴ１Ｂがそれぞれ「第１の電力用半導体素子」にあたる。

【００７６】既述のように、ダイオード１Ａはシリコン基板の両主面に対応する両主面（表面１ＡＳ１及び裏面１ＡＳ２）を有しており、表面１ＡＳ１に表面電極が又裏面１ＡＳ２に裏面電極が形成されている。同様に、ＩＧＢＴ１Ｂにおいても、表面１ＢＳ１に表面電極が又裏面１ＢＳ２に裏面電極が形成されている。なお、図面の煩雑化を避けるため、図１４ではダイオード１Ａ及びＩＧＢＴ１Ｂそれぞれの表面電極及び裏面電極の詳細な図示化は省略している。

【００７７】特に、従来の円筒形のキャパシタ８Ｐとは異なり、キャパシタ２０は、対向する２つの主面２０Ｓ１，２０Ｓ２を有する平板形のキャパシタから成る。そして、平板形の一方の主面（以下、裏面とも呼ぶ）２０Ｓ２に電極（図示せず；裏面電極とも呼ぶ）が形成されており、他方の主面（以下、表面とも呼ぶ）２０Ｓ１に電極（図示せず；表面電極とも呼ぶ）が形成されている。

【００７８】ダイオード１Ａ，ＩＧＢＴ１Ｂ及びキャパシタ２０の各裏面電極はヒートシンク２Ｂが例えば半田

によりヒートシンク２Ｃに接着されている。これにより、各表面電極同士が導電性のヒートシンク２Ｂを介して電気的に接続されている。他方、ダイオード１Ａ，ＩＧＢＴ１Ｂ及びキャパシタ２０の各表面電極（ヒートシンク２Ｂとは対面していない）同士はワイヤ７によって結線されている。なお、圧接や導電性接着剤等によって、各表面電極間を電気的に接続しても構わない。

【００７９】パワーモジュール１１１によれば以下の効果を得ることができる。まず、小型軽量で信頼性の高いパワーモジュール１１１を提供することができる。

【００８０】詳細には、ダイオード１Ａ及びＩＧＢＴ１Ｂ及びキャパシタ２０がヒートシンク２Ｃ上に直付けされている。このため、これらが別々に設けられている従来のパワーモジュール１０１Ｐ～１０３Ｐよりも、パワーモジュールを小型化することができる。また、ヒートシンク２Ｃの放熱作用によってダイオード１Ａ及びＩＧＢＴ１Ｂの発熱のみならずキャパシタ２０の温度上昇をも抑制することができるため、キャパシタ２０の小型化、低インダクタンス化、長寿命化が図れる。

【００８１】更に、ダイオード１Ａ，ＩＧＢＴ１Ｂ及びキャパシタ２０がヒートシンク２Ｃ上に直付けされているので、ダイオード１Ａ及びＩＧＢＴ１Ｂとキャパシタ２０との間を結ぶ配線の長さを従来のパワーモジュール１０１Ｐ～１０３Ｐよりも短くすることができる。特に、ヒートシンク２Ｃは導電性を有するので、ダイオード１Ａ，ＩＧＢＴ１Ｂ及びキャパシタ２０はヒートシンク２Ｃが最短経路で電気的に結ばれている。このため、従来のパワーモジュール１０１Ｐ～１０３Ｐよりも回路インダクタンスを低減することができる。従って、ダイオード１Ａ及びＩＧＢＴ１Ｂのスイッチング動作時に生じる跳ね上がり電圧（オーバーシュート）を低減でき、その結果、ダイオード１Ａ及びＩＧＢＴ１Ｂの耐圧及び損失を低減することができる。また、配線長が短くなることに起因して、電磁ノイズの発生を低減することができる。

【００８２】また、パワーモジュール１１１によれば、ヒートシンク２Ｃが導電性を有するので、当該ヒートシンク２Ｃを電極として用いることができる。このため、例えば、絶縁性のヒートシンクの場合に必要な配線等の部品点数及びそれの形成工程を削減することができる。

【００８３】なお、ヒートシンク２Ｂの貫通孔２ＢＨに冷媒を流すことによって、ヒートシンク２Ｂの冷却能力を向上することができる。

【００８４】＜実施の形態６の変形例１＞なお、ヒートシンク２Ｂに変えて、図１５に示すパワーモジュール１１１Ａのようにフィン構造を有する導電性のヒートシンク２Ａを適用しても、上述の効果を得ることができる。

【００８５】＜実施の形態６の変形例２＞また、キャパシタ２０，ダイオード１Ａ及びＩＧＢＴ１Ｂを、ヒートシンク２Ｂの異なる表面に配置しても構わない。具体的

には、図１６に示すパワーモジュール１１１Ｂのように、ダイオード１Ａ及びＩＧＢＴ１Ｂをヒートシンク２Ｂの表面２ＢＳ上に配置する一方で、キャパシタ２０を上記表面２ＢＳと交わる他の表面（側面）２ＢＳ３上に配置しても構わない。また、上記表面２ＢＳと対向する表面２ＢＳ２上に配置しても構わない。このような構成はヒートシンク２Ａを用いる場合にも適用可能である。

【００８６】パワーモジュール１１１Ｂによれば、上記パワーモジュール１１１と比較して、パワーモジュールを更に小型軽量化することができる。また、ダイオード１Ａ及びＩＧＢＴ１Ｂの放熱とキャパシタ２０の放熱との干渉が少なくなるので、放熱性を向上することができる。

【００８７】＜実施の形態７＞図１７に実施の形態７に係るパワーモジュール１１２の模式的な外観図を示す。図１７と既述の図１４とを比較すれば分かるように、パワーモジュール１１２は、キャパシタ２０（図１４参照）に変えて、キャパシタ用誘電体３３及びキャパシタ用電極３１を備える。詳細には、導電性のヒートシンク２Ｂとキャパシタ用電極３１とでキャパシタ用誘電体３３が挟み込まれており、ヒートシンク２Ｂとキャパシタ用誘電体３３とキャパシタ用電極３１とで以て上記キャパシタ２０に相当する平板形のキャパシタ３０が構成されている。その他の構成はパワーモジュール１１１と同様である。

【００８８】このとき、キャパシタ用電極３１はキャパシタ２０の表面電極にあたり、ヒートシンク２Ｂは同表面電極にあたる。このため、パワーモジュール１１２では、ダイオード１Ａ及びＩＧＢＴ１Ｂがキャパシタ３０の表面電極上に配置されていると捉えることができる。

【００８９】パワーモジュール１１２によれば、上述のパワーモジュール１１１と同様の効果が得られる。

【００９０】＜実施の形態７の変形例１＞なお、ヒートシンク２Ｂに変えて、図１８に示すパワーモジュール１１２Ａのようにフィン構造を有する導電性のヒートシンク２Ａを適用しても構わない。

【００９１】＜実施の形態７の変形例２＞図１９に実施の形態７の変形例２に係るパワーモジュール１１２Ｂの模式的な外観図を示す。パワーモジュール１１２Ｂでは、パワーモジュール１１１Ｂ（図１６参照）と同様に、キャパシタ用誘電体３２及びキャパシタ用電極３１が、表面２ＢＳとは異なる、ヒートシンク２Ｂの表面２ＢＳ２上や表面２ＢＳ３上に配置されている。このような構成はヒートシンク２Ａを用いる場合にも適用可能である。パワーモジュール１１２Ｂによれば、上述のパワーモジュール１１１Ｂと同様の効果が得られる。

【００９２】＜実施の形態８＞図２０に実施の形態８に係るパワーモジュール１１１Ｃの模式的な外観図を示す。パワーモジュール１１１Ｃは、いわゆる３相の電圧型電力変換器を成す。

【００９３】パワーモジュール１１１Ｃでは、キャパシタ２０が、その裏面２０Ｓ２をヒートシンク２Ｂの上記表面２ＢＳ２と対面させて、ヒートシンク２Ｂ上に直に配置されている。

【００９４】パワーモジュール１１Ｃは電力変換器のアームを３つ備える。各アームの下アームを成す各１つのダイオード１Ａ及びＩＧＢＴ１Ｂは共に裏面電極をヒートシンク２Ｂに対面させてヒートシンク２Ｂの表面２ＢＳ上に直に配置されている。また、各下アームのダイオード１Ａ及びＩＧＢＴ１Ｂの各表面電極は、それぞれ電力変換器の出力端子を成す電極６０Ｕ，６０Ｖ，６０Ｗに例えばワイヤ７によって電気的に接続されている。なお、各電極６０Ｕ，６０Ｖ，６０Ｗは各絶縁基板（又は各絶縁層）５０Ｕ，５０Ｖ，５０Ｗを介してヒートシンク２Ｂの表面２ＢＳ上に配置されている。

【００９５】他方、各アームの上アームを成す各１つのダイオード１Ａ及びＩＧＢＴ１Ｂ（それぞれが第２の電力用半導体素子にあたる）は、絶縁基板５を介してヒートシンク２Ｂの表面２ＢＳ上に配置されている。このとき、上アームのダイオード１Ａ及びＩＧＢＴ１Ｂの裏面電極は絶縁基板５上の導電層６と電気的に接続されている。各導電層６は各アーム用の電極６０Ｕ，６０Ｖ，６０Ｗに例えばワイヤ７により電気的に接続されている。上アームを成すダイオード１Ａ及びＩＧＢＴ１Ｂの各表面電極は全てのアームに共通の電極６１に例えばワイヤ７により電気的に接続される。

【００９６】電極６１はヒートシンク２Ｂの表面２ＢＳからキャパシタ２０の表面２０Ｓ１にまで延在してキャパシタ２０の表面電極に電気的に接続されている。なお、電極６１は絶縁層５０によってキャパシタ２０の表面電極以外の部分及びヒートシンク２Ｂと絶縁されている。

【００９７】なお、パワーモジュール１１１Ｃでは、電極６１が、高電位側に接続される「第２電極」にあたり、ヒートシンク２Ｂが、低電位側に接続される「第１電極」にあたる。

【００９８】パワーモジュール１１１Ｃによれば、上アームのダイオード１Ａ及びＩＧＢＴ１Ｂは絶縁基板５を介してヒートシンク２Ｂ上に配置されている。このため、導電性のヒートシンク２Ｂ上に、裏面電極の電位が異なるダイオード１Ａ及びＩＧＢＴ１Ｂを混在させて回路を形成することができる。

【００９９】＜実施の形態８の変形例１＞図２１に実施の形態８の変形例１に係るパワーモジュール１１２Ｃの模式的な外観図を示す。上述のパワーモジュール１１１Ｃと同様に、パワーモジュール１１２Ｃは、いわゆる３相の電圧型電力変換器を成す。

【０１００】図２１と既述の図２０とを比較すれば分かるように、パワーモジュール１１２Ｃは、パワーモジュール１１１Ｃのキャパシタ２０に変えて、キャパシタ用電極３１及びキャパシタ用誘電体３３を備える。詳細には、キャパシタ用誘電体３３はヒートシンク２Ｂの表面２ＢＳ２と対面して配置され、ヒートシンク２Ｂとキャパシタ用電極３１とで挟まれている。これにより、ヒートシンク２Ｂとキャパシタ用誘電体３３とキャパシタ用電極３１とで以て上述の平板形のキャパシタ３０が構成されている。その他の構成はパワーモジュール１１１Ｃと同様である。

【０１０１】パワーモジュール１１２Ｃによれば、ダイオード１Ａ及びＩＧＢＴ１Ｂがキャパシタ３０の一方の電極上に配置されていると捉えられ、パワーモジュール１１２と同様の効果を得ることができる。また、上記パワーモジュール１１１Ｃと同様に、絶縁基板５によって裏面電極の電位が異なるダイオード１Ａ及びＩＧＢＴ１Ｂをキャパシタ３０の電極上に混在させることができる。

【０１０２】＜実施の形態９＞図２２及び図２３に実施の形態９に係るパワーモジュール１１３の模式的な外観図を示す。図２３は図２２中の矢印Ａの方向からパワーモジュール１１３を見た場合の外観図（側面図）に相当する。なお、図面の煩雑化を避けるため、図２３では、ダイオード１Ａ，ＩＧＢＴ１Ｂ及びワイヤ７の図示化を省略している。上述のパワーモジュール１１１Ｃと同様に、パワーモジュール１１３は、いわゆる３相の電圧型電力変換器を成す。

【０１０３】図２２と既述の図２０とを比較すれば分かるように、パワーモジュール１１３では、電力変換器の全ての下アームのダイオード１Ａ及びＩＧＢＴ１Ｂが１つの下アーム用のヒートシンク２Ｂの表面２ＢＳ上に直に配置されている。そして、ヒートシンク２Ｂとキャパシタ２０とが表面２ＢＳ２と裏面２０Ｓ２とを対面させて配置されており、ヒートシンク２Ｂとキャパシタ２０の裏面電極とが電気的に接している。

【０１０４】他方、電力変換器の各上アームのダイオード１Ａ及びＩＧＢＴ１Ｂは各上アーム用の導電性を有するヒートシンク（他のヒートシンク）２Ｂ上に直に配置されており、パワーモジュール１１１Ｃ（図２０参照）と同様に電極６１と電気的に接続されている。各上アーム用の３つのヒートシンク２Ｂは互いに絶縁連結されている（図２２では配管２ＢＪの図示化は省略している）と共に、下アーム用のヒートシンク２Ｂ及びキャパシタ２０の裏面電極とは絶縁部材１０によって絶縁されている。なお、絶縁部材１０で以て、４つのヒートシンク２Ｂとキャパシタ２０とが一体的に結合している。

【０１０５】各上アーム用のヒートシンク２Ｂは例えばワイヤ７によって各アーム用の電極６０Ｕ，６０Ｖ，６０Ｗと例えばワイヤ（可撓性の配線）７で電気的に接続されている。特に、当該ワイヤ７は、電極６０Ｕ，６０Ｖ，６０Ｗの内で絶縁部材１０上に配置された部分（導電部材）を中継点ないしは経由点として、上アームと下

アームとを電気的に接続している。

【０１０６】上述のように、パワーモジュール１１３では、絶縁部材１０で以て、４つのヒートシンク２Ｂが互いに絶縁されている。このため、既述のパワーモジュール１１１Ｃ（図２０参照）とは異なり、絶縁基板５を用いることなく、上アーム用のダイオード１Ａ及びＩＧＢＴ１Ｂの裏面電極と、下アーム用の同裏面電極との電位を違えることができる。このため、絶縁基板５の分だけ部品点数を削減できる。

【０１０７】更に、パワーモジュール１１１３では上アーム及び下アームの両構成が大略同等であるので、パワーモジュール全体の製造コストを低減することができる。その結果、安価なパワーモジュール１１３を提供することができる。

【０１０８】また、上述のように上アームと下アームとを結線するワイヤ７は、電極６０Ｕ，６０Ｖ，６０Ｗの内で絶縁部材１０上に配置された部分（導電部材）に接続されている。このため、上記導電部材を介することなく直接に上アームと下アームとの間を接続する場合と比較して、当該配線の撓みないしは垂れを抑えることができる。その結果、配線の垂れによる短絡を防止することができる。

【０１０９】＜実施の形態１０＞図２４及び図２５に実施の形態１０に係るパワーモジュール１１１Ｄの模式的な外観図（側面図）及び縦断面図を示す。図２４と既述の図１１とを比較すれば分かるように、パワーモジュール１１１Ｄは基本的に既述のパワーモジュール１０５にキャパシタ２０を設けた構成を有するので、パワーモジュール１０５と同様の構成については既述の説明を採用するに留め、パワーモジュール１１１Ｄの特徴部分を中心に説明を進める。なお、図２４では図１１と同様に構成要素の一部の図示化を省略している。

【０１１０】なお、電力変換器の３つの下アームはそれぞれヒートシンク２Ｃに直付けされているダイオード１Ａ及びＩＧＢＴ１Ｂで構成され、電力変換器の３つの上アームはそれぞれ絶縁基板５を介してヒートシンク２Ｃ上に配置されているダイオード１Ａ及びＩＧＢＴ１Ｂで構成される。

【０１１１】パワーモジュール１１１Ｄは、導電性のヒートシンク２Ｃの円形の主面２ＣＳ２上にキャパシタ２０が直に配置されている。このとき、キャパシタ２０はその裏面２０Ｓ２をヒートシンク２Ｃに対面させて配置されており、キャパシタ２０の裏面電極２０Ｅ２（図２５参照）とヒートシンク２Ｃとが電気的に接続されている。

【０１１２】特に、パワーモジュール１１１Ｄでは電極６１，６２の接続形態が既述のパワーモジュール１０５とは異なる。詳細には、図２５に示すように、棒状の電極６１はヒートシンク２Ｃ及びキャパシタ２０（表面電極２０Ｅ１を除く）を貫いて延在し、キャパシタ２０の

表面電極２０Ｅ１と電気的に接続されている。このとき、電極６１と共に絶　部材１１も伸長されており、電極６１がヒートシンク２Ｃ及びキャパシタ２０（表面電極２０Ｅ２を除く）から絶　されている。他方、筒状の電極６２は絶縁基板５０Ｃを貫いて配置されており、ヒートシンク２Ｃと電気的に接続されている。

【０１１３】パワーモジュール１１１Ｄでは、電極６１が、電力変換器の高電位側に接続される「第２電極」にあたり、電極６２が、低電位側に接続される「第１電極」にあたる。

【０１１４】パワーモジュール１１１Ｄによれば、既述のパワーモジュール１０５と同様に、同軸線を取り囲む３つのアームの配置に起因して信頼性の高い電力変換器を提供することができると共に、従来のパワーモジュール１０３Ｐよりも小型軽量な電力変換器を提供することができる。

【０１１５】＜実施の形態１０の変形例１＞図２６及び図２７に実施の形態１０の変形例１に係るパワーモジュール１１２Ｄの模式的な外観図及び縦断面図を示す。上述のパワーモジュール１１１Ｄと同様に、パワーモジュール１１２Ｄは、いわゆる３相の電圧型電力変換器を成す。

【０１１６】図２６と既述の図２４とを比較すれば分かるように、パワーモジュール１１２Ｄは、パワーモジュール１１１Ｄのキャパシタ２０に変えて、キャパシタ用電極３１及びキャパシタ用誘電体３３を備える。詳細には、キャパシタ用誘電体３３はヒートシンク２Ｃの主面２ＣＳ２と対面して配置され、ヒートシンク２Ｂとキャパシタ用電極３１とで挟まれている。これにより、ヒートシンク２Ｂとキャパシタ用誘電体３３とキャパシタ用電極３１とで以て上述の平板形のキャパシタ３０が構成されている。そして、パワーモジュール１１１Ｄと同様に、パワーモジュール１１２Ｄの棒状の電極６１は、ヒートシンク２Ｃ，キャパシタ用誘電体３３を貫いて延在し、キャパシタ用電極３１と電気的に接続されている。その他の構成はパワーモジュール１１１Ｄと同様である。このため、パワーモジュール１１１Ｄと同様の効果を得ることができる。

【０１１７】また、パワーモジュール１１２Ｄでは、ダイオード１Ａ及びＩＧＢＴ１Ｂがキャパシタ３０の裏面電極上に配置されていると捉えられ、パワーモジュール１１２と同様の効果を得ることができる。

【０１１８】＜実施の形態１１＞図２８～図３０に実施の形態１１に係るパワーモジュール１１１Ｅの模式図を示す。なお、パワーモジュール１１１Ｅは上述のパワーモジュール１１１Ｄを基本としているため、又、図面の煩雑化を避けるため、図２８では一部のワイヤ７の図示化を省略し又図２９及び図３０では電極６０Ｕ，６０Ｖ，６０Ｗ等の図示化を省略している。

【０１１９】上述のモジュール１１１Ｄではダイオード

１Ａ及びＩＧＢＴ１Ｂが全てヒートシンク２Ｃの一方の主面２ＣＳ１上に配置されているのに対して、パワーモジュール１１１Ｅではダイオード１Ａ及びＩＧＢＴ１Ｂがヒートシンク２Ｃの主面２ＣＳ１とキャパシタ２０の表面２０Ｓ１とに分散して配置されている。

【０１２０】詳細には、導電性を有するヒートシンク２Ｃの主面２ＣＳ１上に、電力変換器の下アームを成すダイオード１Ａ及びＩＧＢＴ１Ｂが直に配置されている（図２９参照）。そして、当該ダイオード１Ａ及びＩＧＢＴ１Ｂの表面電極同士が接続されている。他方、キャパシタ２０の表面２０Ｓ１上に（詳細には表面電極上に）、絶縁基板５が配置されており、絶縁基板５の導電層６上に、電力変換器の上アームを成すダイオード１Ａ及びＩＧＢＴ１Ｂが配置されている（図３０参照）。絶縁基板５上のダイオード１Ａ及びＩＧＢＴ１Ｂの表面電極はヒートシンク２Ｃに接続されている。

【０１２１】更に、上アームのＩＧＢＴ１Ｂの裏面電極と導通する導電層６と下アームのＩＧＢＴ１Ｂの表面電極とが接続されて電力変換器のアームを成す（配線７Ｂ参照）。３つのアームにおける上記接続点が電極６０Ｕ，６０Ｖ，６０Ｗを成す。パワーモジュール１１１Ｅによっても、パワーモジュール１１１Ｄと同様の効果が得られる。

【０１２２】なお、パワーモジュール１１１Ｅでは、ヒートシンク２Ｃが低電位側に接続され、キャパシタ２０の表面電極が高電位側に接続される。このとき、図２８～図３０への図示化は省略しているが、パワーモジュール１１１Ｄと同様の接続形態を有する同軸線（図２５参照）によって給電しても構わず、かかる場合には電極６２が「第１電極」にあたり、電極６１が「第２電極」にあたる。

【０１２３】また、上述のパワーモジュール１１１Ｄとパワーモジュール１１２Ｄとの関係のように、パワーモジュール１１１Ｅのキャパシタ２０をキャパシタ用誘電体３３及びキャパシタ用電極３１に変更しても構わない。

【０１２４】＜実施の形態１２＞図３１に実施の形態１２に係るパワーモジュール２０１の模式的な外観図を示す。パワーモジュール２０１は、２つの凹部（空間）２０２Ｋを有する絶縁性の筐体２０２を備える。筐体２０２の各凹部２０２Ｋ内には、ダイオード１Ａが直付けされたヒートシンク２ＢとＩＧＢＴ１Ｂが直付けされたヒートシンク２Ｂとが例えば交互に並べられて１列に収納されている。なお、図３１ではダイオード１Ａ及びＩＧＢＴ１Ｂの結線の図示化は省略している。

【０１２５】この際、各凹部２０２Ｋ内において各ヒートシンク２Ｂは隙間２０３を空けて並べられており、各隙間２０３間がヒートシンク２Ｂの貫通孔２ＢＨで空間的に繋がれるように各ヒートシンク２Ｂ又は貫通孔２ＢＨの向きが定められている。また、各凹部２０２Ｋの内

面とヒートシンク２Ｂとの間に隙間２０３以外の隙間ができないように、ヒートシンク２Ｂ及び凹部２０２Ｋの寸法が規定されている。

【０１２６】各凹部２０２Ｋにおいてヒートシンク２Ｂの並びの両端には隙間２０３が設けられており、各筐体２０２には当該各隙間２０３と繋がる穴が形成されている。そして、各凹部２０２Ｋの各一方の穴にはそれぞれ配管２ＢＪが接続されており、各他方の穴は互いに配管２ＢＪで繋がれて凹部２０２Ｋ同士が連結されている。

【０１２７】隙間２０３には、筐体２０２の一部である絶縁性の蓋（図示せず）が被せられおり、これにより両凹部２０２Ｋがいわば一続きの空間を成す。このため、パワーモジュール２０１では、一方の凹部２０２Ｋの上記一方の穴から冷媒を流し込み、両凹部２０２Ｋ内に冷媒を流すことができる。このとき、筐体２０２及び上記蓋が共に絶縁性なので、例えば絶縁性の冷媒を用いれば各ヒートシンク２Ｂ間を絶縁することができる（絶縁連結）。なお、絶縁性の冷媒として、例えば空気，六フッ化硫黄（SF_6）等の気体や、油，フロリーナ等の液体が挙げられる。また、例えば導電性の冷媒を用いれば導電性のヒートシンク２Ｂ同士を同電位に設定可能である（導電連結）。また、絶縁性のヒートシンク２Ｂと導電性のヒートシンク２Ｂとを組み合わせ、導電性の冷媒を用いれば所望の導電性のヒートシンク２Ｂのみを導電連結することができる。

【０１２８】さて、ダイオード１Ａ及び／又はＩＧＢＴ１Ｂを絶縁基板５を介してヒートシンク２Ｂ上に配置しても良く、かかる場合には導電性のヒートシンク２Ｂを用いた場合であっても所望のダイオード１Ａ及び／又はＩＧＢＴ１Ｂを他から絶縁することができる。逆に言えば、上述のようにヒートシンク２Ｂの導電性／絶縁性によって絶縁基板５を不要としうる。なお、１つのヒートシンク２Ｂ上に複数の電力用半導体素子を配置しても構わない。

【０１２９】上述のように各ヒートシンク２Ｂは隙間２０３を空けて並べられているので、冷媒は隙間２０３と隙間２０３よりも狭い貫通孔２ＢＨとを交互に通過する。このとき、冷媒が貫通孔２ＢＨを通る時、換言すれば発熱体であるダイオード１Ａ及びＩＧＢＴ１Ｂの下方を通る時は、隙間２０３を通る時よりも、冷媒は速く流れる。これにより、冷却効果を増大させることができる。他方、隙間部２０３における冷媒の流れは貫通孔２ＢＨにおけるそれよりも遅いので、圧力損失を抑えることができる。従って、パワーモジュール２０１によれば、より高い冷却性能をより低い圧力損失で以て実現することができる。

【０１３０】また、上述のように、絶縁性の冷媒を用いることによって、絶縁基板５を用いることなく、換言すれば導電性のヒートシンク２Ｂ上にダイオード１Ａ及び／又はＩＧＢＴ１Ｂを直に配置する場合であっても、各

電力用半導体素子を互いに絶　することができる。このため、絶縁性の冷媒を用いることによって、絶縁基板５の分だけ部品点数を削減できる。更に、ダイオード１Ａ及び／又はＩＧＢＴ１Ｂを搭載した各ヒートシンク２Ｂはそれぞれ大略同等であるので、パワーモジュール全体の製造コスト及び価格を低減することができる。

【０１３１】更に、上述の各電力用半導体素子が互いに絶縁されることに起因して、各電力用半導体素子を導電性のヒートシンク２Ｂ上に直に配置可能である。従って、パワーモジュールの放熱性能を向上することができ、その結果、信頼性を向上させることができる。

【０１３２】＜実施の形態１３＞図３２に実施の形態１３に係るパワーモジュール１１４の模式的な外観図を示す。図３２に示すように、パワーモジュール１１４は、既述の図２２に示すパワーモジュール１１３に対して電流測定用のシャント抵抗９０を更に備える。詳細には、シャント抵抗９０は電極６０Ｕ，６０Ｖ，６０Ｗの出力端にそれぞれ直接、接続されており、各シャント抵抗９０が電力変換器の各出力端子を成している。

【０１３３】パワーモジュール１１４ではシャント抵抗により電流を計測するので、従来のパワーモジュール１０１Ｐ等で用いられる変流器９２Ｐとは異なり、制御電源が不要であるし、原理的にオフセットが無い。

【０１３４】また、シャント抵抗９０は電極６０Ｕ，６０Ｖ，６０Ｗの出力端に直接に接続されているので、変流器９２Ｐがケースの外に別個に設けられている従来のパワーモジュール１０１等と比較して、パワーモジュール全体を小型軽量化することができるし、電流計測用部品の点数を削減することができる。

【０１３５】＜実施の形態１３の変形例１＞図３３に実施の形態１３の変形例１に係るパワーモジュール１１４Ａの模式的な外観図を示す。図３３と上述の図３２とを比較すれば分かるように、パワーモジュール１１４Ａの各シャント抵抗９０はヒートシンク２Ｂの表面２ＢＳに対面する位置に設けられて各電極６０Ｕ，６０Ｖ，６０Ｗと直接に接続されている。

【０１３６】パワーモジュール１１４Ａによれば、ヒートシンク９０の作用によりシャント抵抗９０の温度上昇を抑制することができる。このため、温度変化に起因したシャント抵抗の特性変化を大幅に抑制することができ、その結果、電流量の検出精度をさらに向上することができる。また、シャント抵抗９０がヒートシンク２Ｂの上方に配置されているので、上述のパワーモジュール１１４と比較して更に小型化可能である。

【０１３７】

【発明の効果】（１）請求項１に係る発明によれば、第１の電力用半導体素子及びキャパシタが共にヒートシンク上に直付けされている。このため、両者が別々に設けられている従来のパワーモジュールよりも、パワーモジュールを小型軽量化することができる。また、ヒートシンクの放熱作用によって第１の電力用半導体素子の発熱のみならずキャパシタの温度上昇をも抑制することができるため、キャパシタの小型化、低インダクタンス化、長寿命化が図れる。

【０１３８】更に、第１の電力用半導体素子及びキャパシタが共にヒートシンク上に直付けされているので、両者の間を結ぶ配線の長さを上述の従来のパワーモジュールよりも短くすることができる。このため、回路インダクタンスを低減することができる。従って、第１の電力用半導体素子のスイッチング動作時に生じる跳ね上がり電圧（オーバーシュート）を低減でき、その結果、第１の電力用半導体素子の耐圧及び損失を低減することができる。また、配線長が短くなることに起因して、電磁ノイズの発生を低減することができる。

【０１３９】従って、小型軽量で信頼性の高いパワーモジュールを提供することができる。

【０１４０】（２）請求項２に係る発明によれば、第１の電力用半導体素子とキャパシタとはヒートシンクの異なる表面上に配置されているので、両者を同一表面上に配置する場合と比較して、パワーモジュールを更に小型軽量化することができる。また、第１の電力用半導体素子の放熱とキャパシタの放熱との干渉が少なくなるので、放熱性を向上することができる。

【０１４１】（３）請求項３に係る発明によれば、ヒートシンクの流路に冷媒を流すことによって、ヒートシンクの冷却能力を更に向上することができる。

【０１４２】（４）請求項４に係る発明によれば、ヒートシンクは導電性を有するので、ヒートシンクを電極として用いることができる。このため、例えばヒートシンク上の配線等の部品点数及びそれの形成工程を削減することができる。

【０１４３】更に、第１の電力用半導体素子の電極及びキャパシタの電極がヒートシンクと直に接着されている。即ち、第１の電力用半導体素子とキャパシタとがヒートシンクを介して電気的に接続されている。このため、両電極間をワイヤ等の配線で接続する場合よりも更に両電極間の電気的接続を短くすることができる。その結果、回路インダクタンスの更なる低減により、上記跳ね上がり電圧（オーバーシュート）等を格段に低減することができる。

【０１４４】（５）請求項５に係る発明によれば、第２の電力用半導体素子が絶縁基板を介してヒートシンク上に配置されている。このため、導電性のヒートシンク上に電位の異なる電力用半導体素子を配置して回路を構成することができる。

【０１４５】（６）請求項６に係る発明によれば、他のヒートシンク上に配置された第２の電力用半導体素子を更に備える。このため、第１の電力用半導体素子と第２の電力用半導体素子とを組み合わせにより、回路を簡単に構成することができる。

【０１４６】（７）請求項７に係る発明によれば、導電性の他のヒートシンクは、絶縁部材によって上記導電性のヒートシンク及びキャパシタの電極から絶縁されているので、絶　基板を用いることなく、第１の電力用半導体素子と第２の電力用半導体素子との電位を違えることができる。このため、絶縁基板の分だけ部品点数を削減できる。更に、第１の電力用半導体素子及びヒートシンクを含む構成と、第２の電力用半導体素子及びヒートシンクを含む構成とは大略同等であるので、パワーモジュール全体の製造コストを低減することができる。その結果、安価なパワーモジュールを提供することができる。

【０１４７】（８）請求項８に係る発明によれば、第１の電力用半導体素子と第２の電力用半導体素子とは、絶縁部材上に配置された導電部材を中継点とする可撓性の配線、例えばワイヤによって電気的に接続されている。このため、上記導電部材を介することなく直接に両電力用半導体素子間を可撓性の配線を電気的に接続する場合と比較して、当該配線の撓みないしは垂れを抑えることができる。その結果、配線の垂れによる短絡を防止することができる。

【０１４８】（９）請求項９に係る発明によれば、キャパシタの電極上に第１の電力用半導体素子が直付けされている。このため、両者が別々に設けられている従来のパワーモジュールよりも、パワーモジュールを小型軽量化することができる。また、キャパシタの電極をヒートシンクとして用いることによって、当該ヒートシンクの放熱作用によって、第１の電力用半導体素子の発熱のみならず、キャパシタの温度上昇をも抑制することができる。

【０１４９】更に、キャパシタの電極上に第１の電力用半導体素子が直付けされているので、両者の間の電気的接続を上述の従来のパワーモジュールよりも大幅に短くすることができる。これにより、回路インダクタンスを低減することができる。従って、第１の電力用半導体素子のスイッチング動作時に生じる跳ね上がり電圧（オーバーシュート）を低減でき、その結果、第１の電力用半導体素子の耐圧及び損失を低減することができる。また、配線長が短くなることに起因して、電磁ノイズの発生を低減することができる。

【０１５０】従って、小型軽量で信頼性の高いパワーモジュールを提供することができる。

【０１５１】（１０）請求項１０に係る発明によれば、キャパシタの電極が有する流路に冷媒を流すことによって、パワーモジュールの冷却能力を更に向上することができる。

【０１５２】（１１）請求項１１に係る発明によれば、第２の電力用半導体素子が絶縁基板を介してキャパシタの電極上に配置されている。このため、キャパシタの電極上に電位の異なる電力用半導体素子を配置して回路を構成することができる。

【０１５３】（１２）請求項１２に係る発明によれば、信頼性の高い電力変換器を提供することができる。

【０１５４】（１３）請求項１３に係る発明によれば、電力変換器の複数のアームは、同軸線を取り囲んで同心円上に略等間隔で配置されている。このため、第１電極及び第２電極と各アームとの間の配線を同様に形成することができるので、各アームから取り出される各出力のばらつきを小さくすることができると共に、第１電圧側の変動を小さくできるため誤動作に強くすることができる。

【０１５５】（１４）請求項１４に係る発明によれば、複数のヒートシンクは筐体の空間内に隙間及びヒートシンクの流路から成る一続きの空間を形成する。このとき、冷媒がヒートシンクの流路を流れる際には隙間を流れる場合よりも冷媒の流速を速くすることできるので、ヒートシンクの高い冷却性能を得ることができる。他方、冷媒が隙間を流れる際には上記流路を流れる場合よりも冷媒の圧力損失を小さくすることができる。即ち、より高い冷却性能をより低い圧力損失で以て実現することができる。

【０１５６】（１５）請求項１５に係る発明によれば、ヒートシンクの流路に流される冷媒は絶縁性であるので、絶縁基板を用いることなく、換言すれば導電性のヒートシンク上に電力用半導体素子を直に配置する場合であっても、各電力用半導体素子を互いに絶縁することができる。このため、絶縁基板の分だけ部品点数を削減できる。更に、電力用半導体素子及びヒートシンクを含む構成はそれぞれ大略同等であるので、パワーモジュール全体の製造コストを低減することができる。その結果、安価なパワーモジュールを提供することができる。

【０１５７】また、上述の各電力用半導体素子が互いに絶縁されることに起因して、各電力用半導体素子を導電性のヒートシンク上に直に配置可能である。従って、パワーモジュールの放熱性能を向上することができ、信頼性の高いパワーモジュールを提供することができる。

【図面の簡単な説明】

【図１】　実施の形態１に係るパワーモジュールの模式的な外観図である。

【図２】　実施の形態２に係るパワーモジュールの模式的な外観図である。

【図３】　実施の形態３に係るパワーモジュールの模式的な外観図である。

【図４】　実施の形態４に係るパワーモジュールの模式的な外観図である。

【図５】　実施の形態４の変形例１に係るパワーモジュールの模式的な外観図である。

【図６】　実施の形態４の変形例２に係るパワーモジュールの模式的な外観図である。

【図７】　実施の形態４の変形例２に係るパワーモジュールの模式的な外観図である。

【図８】　実施の形態４の変形例３に係るパワーモジュールの模式的な外観図である。

【図９】　実施の形態４の変形例４に係るパワーモジュールの模式的な外観図である。

【図１０】　実施の形態５に係るパワーモジュールの模式的な外観図である。

【図１１】　実施の形態５に係るパワーモジュールの模式的な外観図である。

【図１２】　実施の形態５に係るパワーモジュールの模式的な縦断面図である。

【図１３】　実施の形態５に係るパワーモジュールが有する貫通孔を説明するための模式図である。

【図１４】　実施の形態６に係るパワーモジュールの模式的な外観図である。

【図１５】　実施の形態６の変形例１に係るパワーモジュールの模式的な外観図である。

【図１６】　実施の形態６の変形例２に係るパワーモジュールの模式的な外観図である。

【図１７】　実施の形態７に係るパワーモジュールの模式的な外観図である。

【図１８】　実施の形態７の変形例１に係るパワーモジュールの模式的な外観図である。

【図１９】　実施の形態７の変形例２に係るパワーモジュールの模式的な外観図である。

【図２０】　実施の形態８に係るパワーモジュールの模式的な外観図である。

【図２１】　実施の形態８の変形例１に係るパワーモジュールの模式的な外観図である。

【図２２】　実施の形態９に係るパワーモジュールの模式的な外観図である。

【図２３】　実施の形態９に係るパワーモジュールの模式的な外観図である。

【図２４】　実施の形態１０に係るパワーモジュールの模式的な外観図である。

【図２５】　実施の形態１０に係るパワーモジュールの模式的な縦断面図である。

【図２６】　実施の形態１０の変形例１に係るパワーモジュールの模式的な外観図である。

【図２７】　実施の形態１０の変形例１に係るパワーモジュールの模式的な外観図である。

【図２８】　実施の形態１１に係るパワーモジュールの模式図である。

【図２９】　実施の形態１１に係るパワーモジュールの模式図である。

【図３０】　実施の形態１１に係るパワーモジュールの模式図である。

【図３１】　実施の形態１２に係るパワーモジュールの模式的な外観図である。

【図３２】　実施の形態１３に係るパワーモジュールの模式的な外観図である。

【図３３】　実施の形態１３の変形例１に係るパワーモジュールの模式的な外観図である。

【図３４】　第１の従来のパワーモジュールの模式的な外観図である。

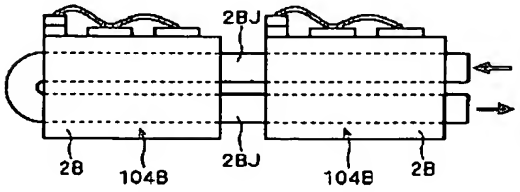
【図３５】　第２の従来のパワーモジュールの模式的な外観図である。

【図３６】　第３の従来のパワーモジュールの模式的な外観図である。

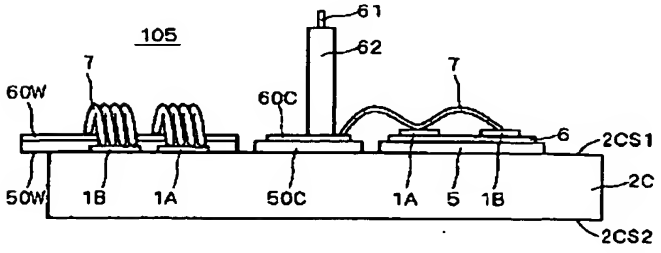
【符号の説明】

１　電力用半導体素子、１Ａ　フリーホイーリングダイオード（電力用半導体素子）、１Ｂ　絶縁ゲート型バイポーラトランジスタ（電力用半導体素子）、２Ａ，２Ｂ，２Ｃ　ヒートシンク、２ＡＳ，２ＢＳ，２ＢＳ２，２ＢＳ３　表面、２ＣＳ１，２ＣＳ２　主面（表面）、２ＢＨ　貫通孔（流路）、４　絶縁層、５，５０Ｃ，５０Ｕ，５０Ｖ，５０Ｗ　絶縁基板、６０Ｃ　導電層、６０Ｕ，６０Ｖ，６０Ｗ　電極（導電部材）、７　ワイヤ（可撓性の配線）、１０　絶縁部材、２０，３０　キャパシタ、２０Ｅ１，２０Ｅ２　電極、３１　キャパシタ用電極、３３　キャパシタ用誘電体、５０　絶縁層（絶縁部材）、６１，６２　電極、１０１～１０５，１０４Ａ～１０４Ｄ，１１１～１１４，１１１Ａ～１１１Ｅ，１１２Ａ～１１２Ｄ，１１４Ａ，２０１　パワーモジュール、２０２　筐体、２０２Ｋ　凹部（空間）。

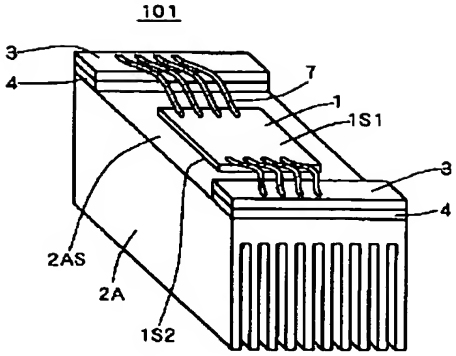
【図７】



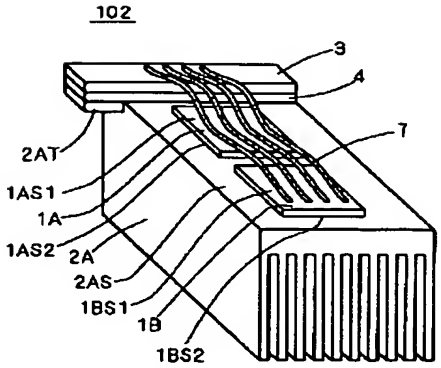
【図１１】



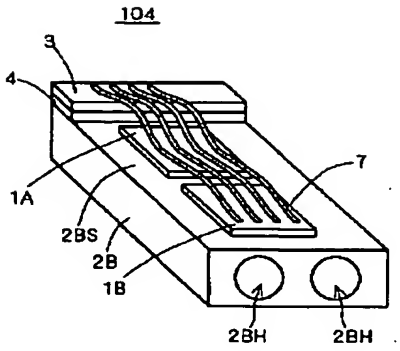
【図１】



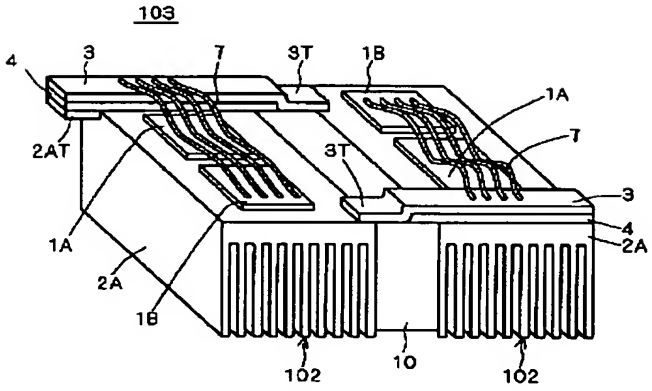
【図２】



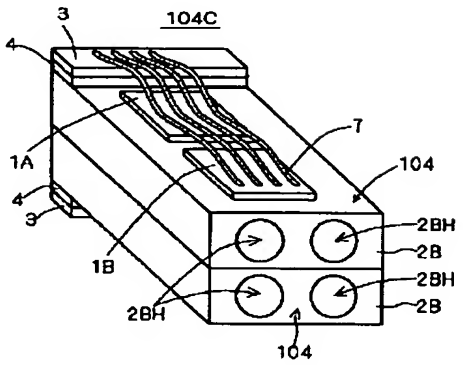
【図４】



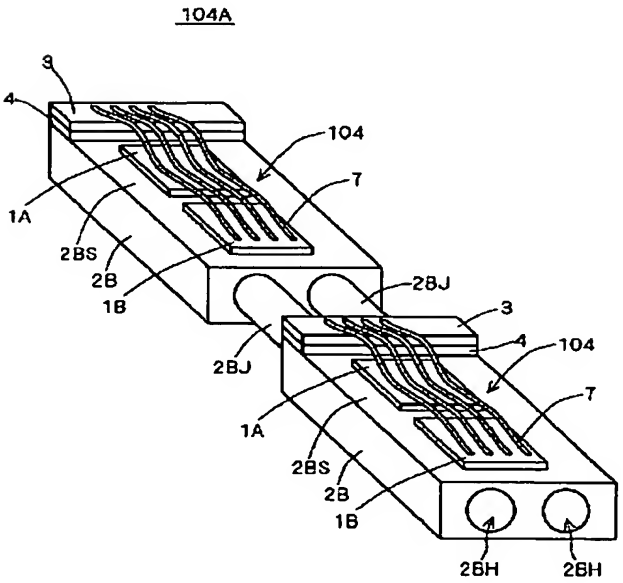
【図３】



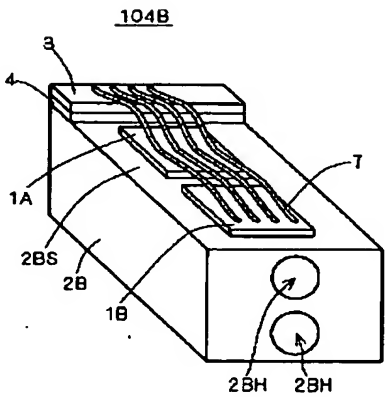
【図８】



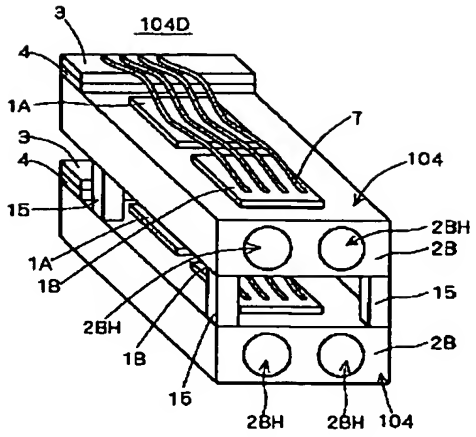
【図５】



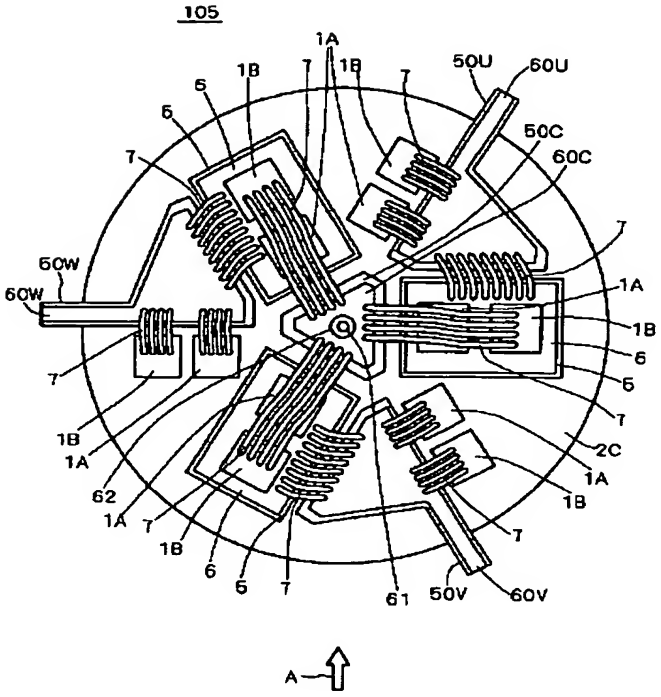
【図６】



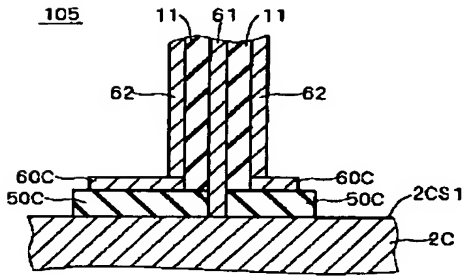
【図９】



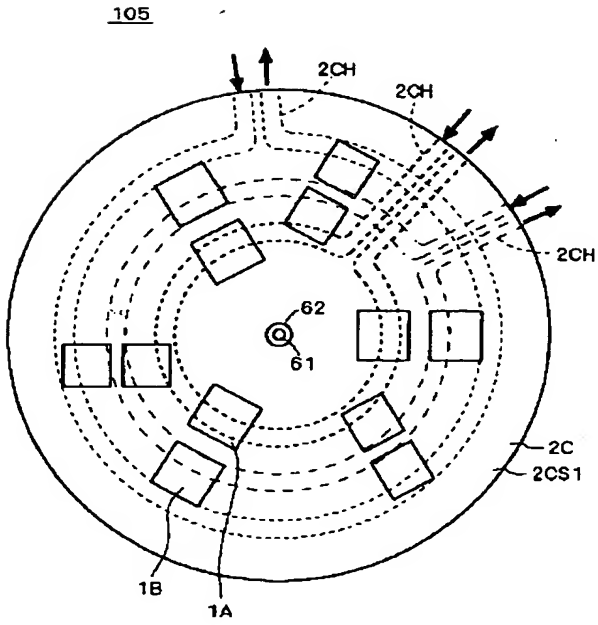
【図１０】



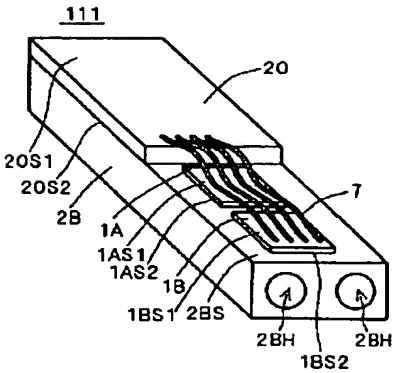
【図１２】



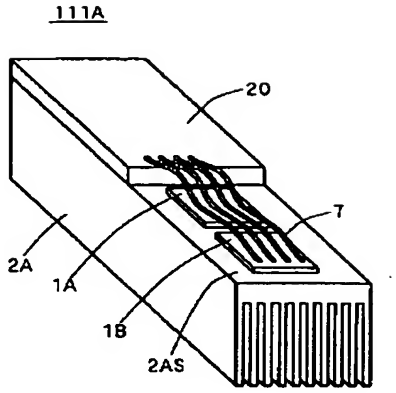
【図１３】



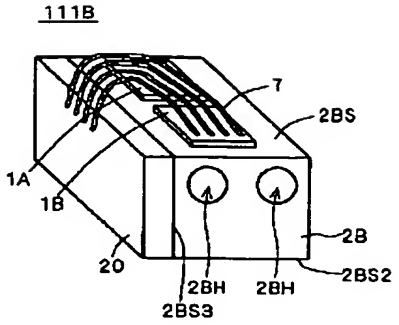
【図１４】



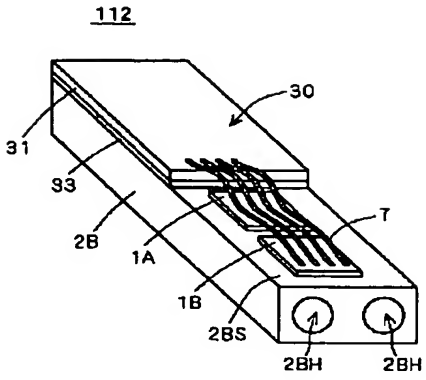
【図１５】



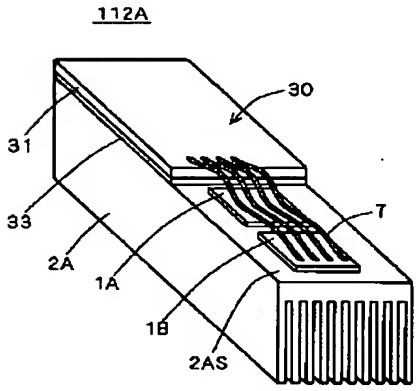
【図１６】



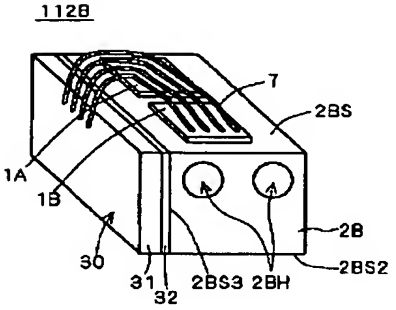
【図１７】



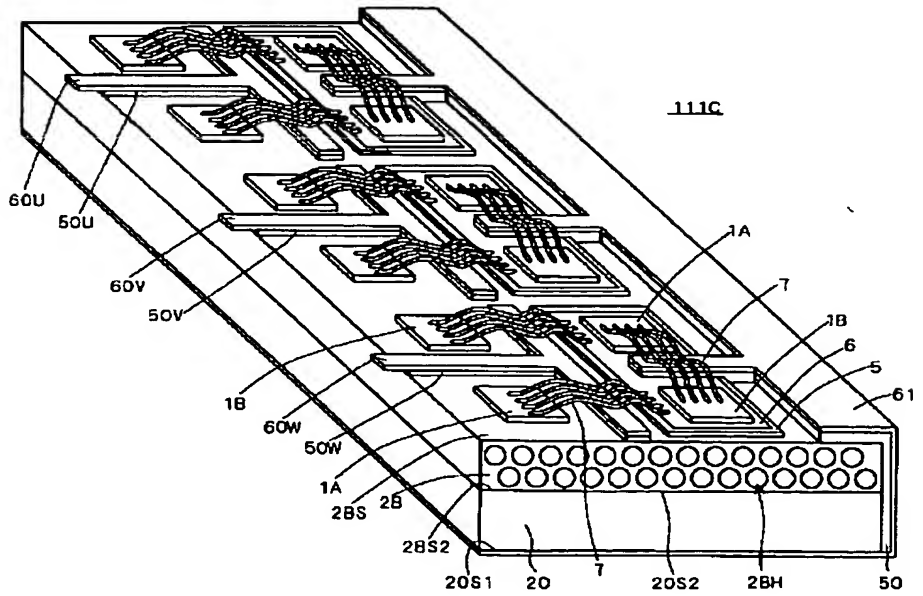
【図１８】



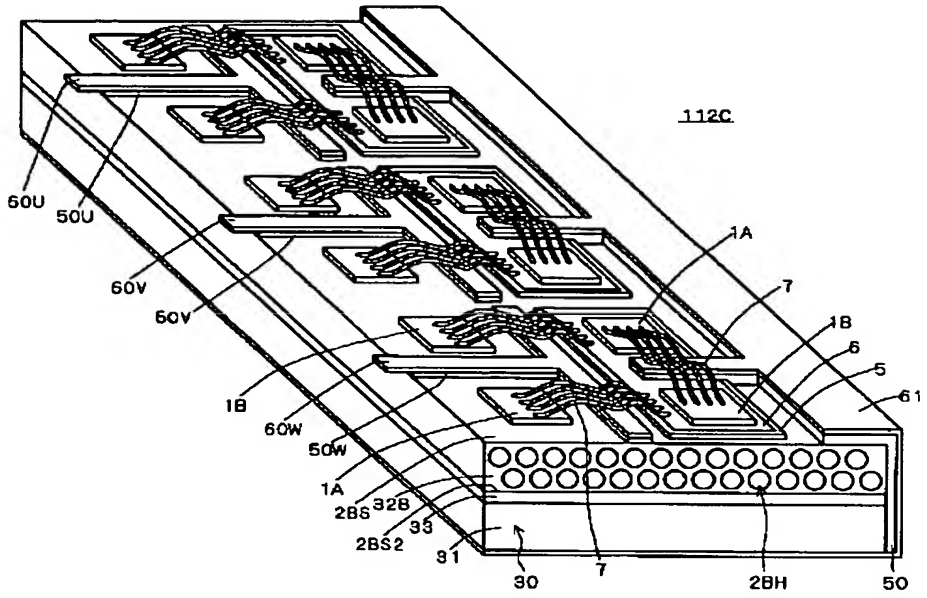
【図１９】



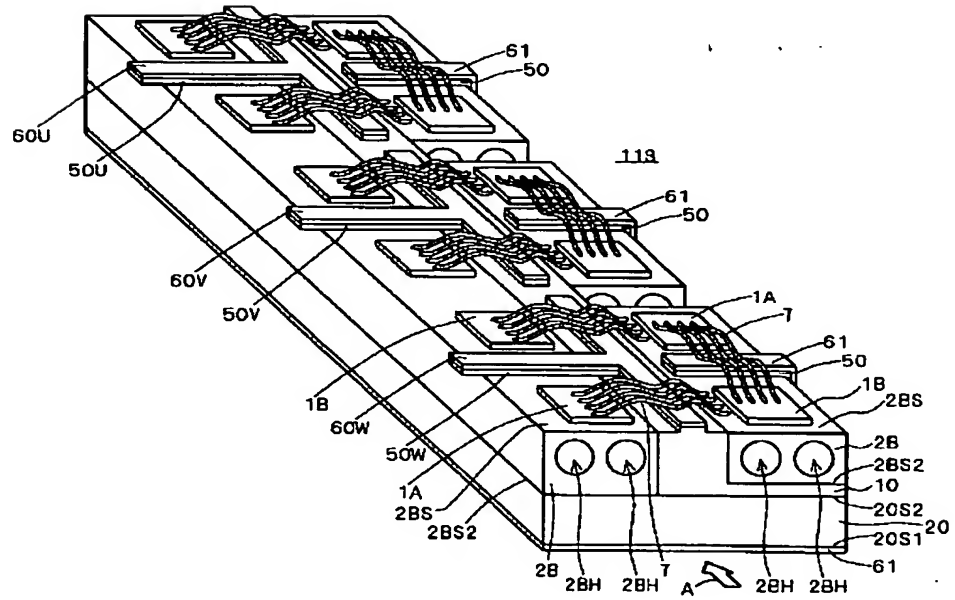
【図２０】



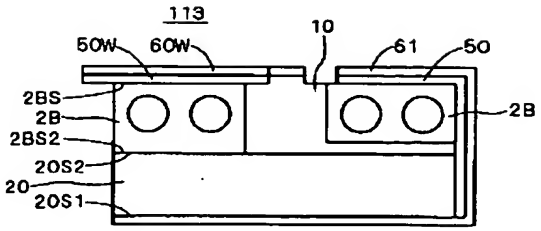
【図２１】


112C
60U
50U
60V
50V
1B
60W
50W
1A
2BS
32B
35
2BS2
31
30
7
2BH
50
61
5
6
1B
7
1A

【図２２】


119
60U
50U
60V
50V
1B
60W
50W
1A
2BS
2BS2
61
50
1A
7
61
50
1B
2BS
2B
2BS2
10
20S2
20
20S1
61
2B
2BH
2BH
7
A
2BH
2BH

【図２３】



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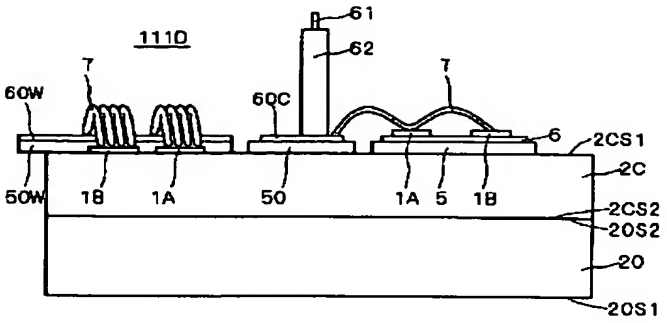

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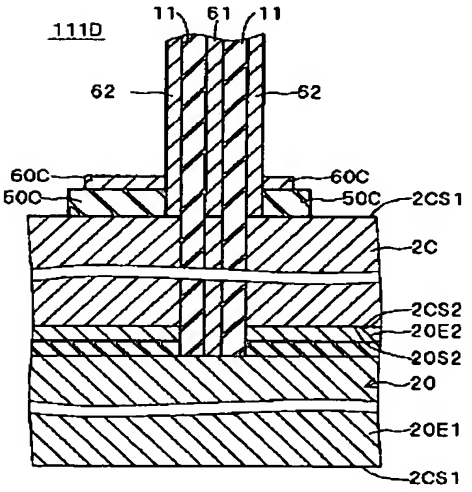

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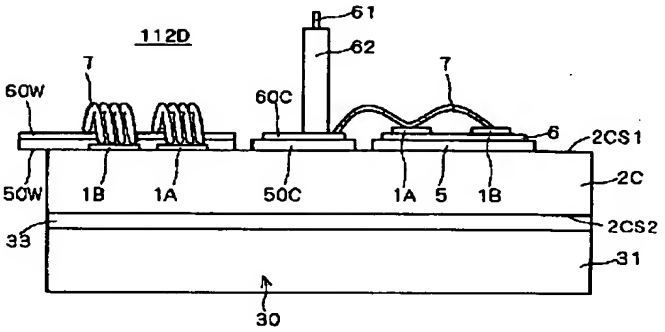

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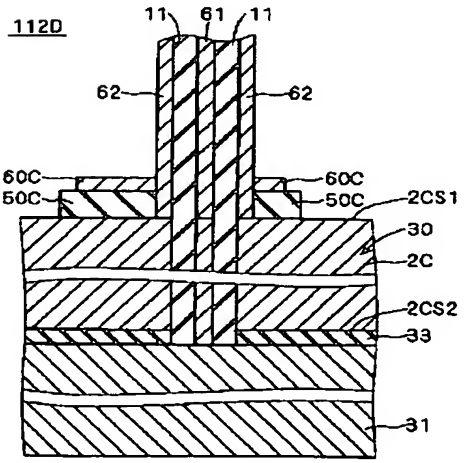

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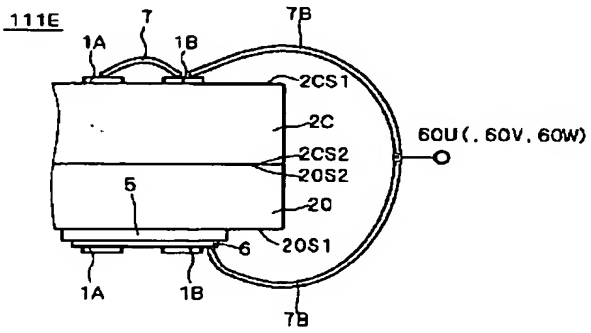

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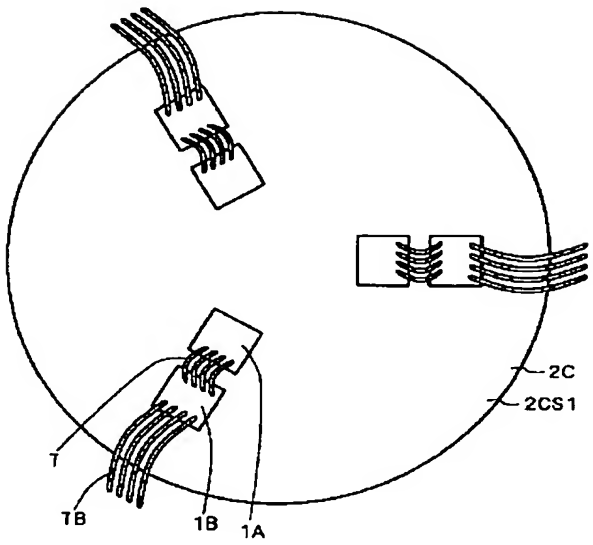
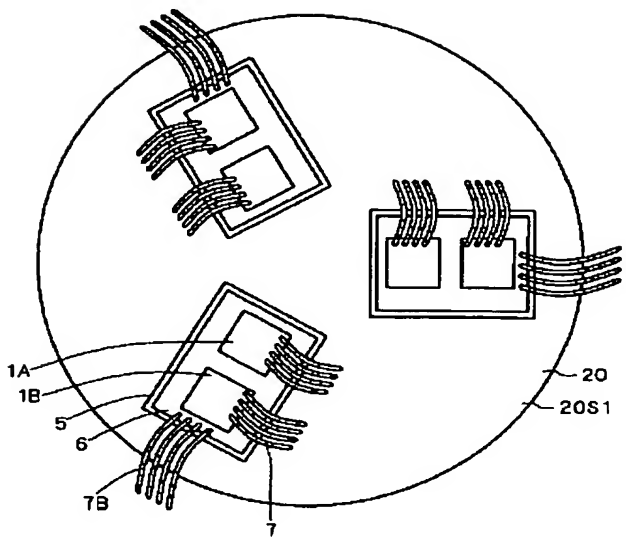


【図３０】



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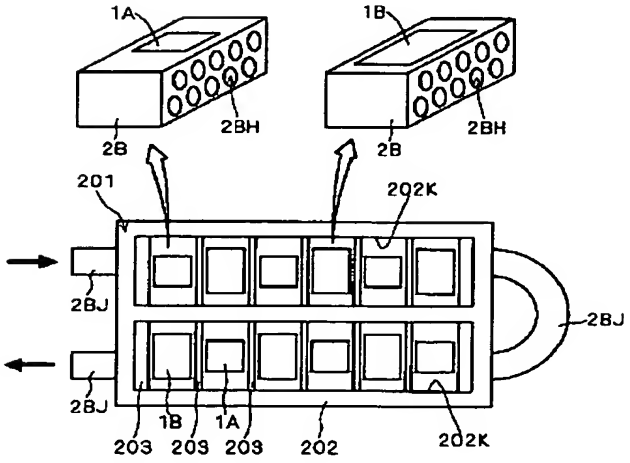

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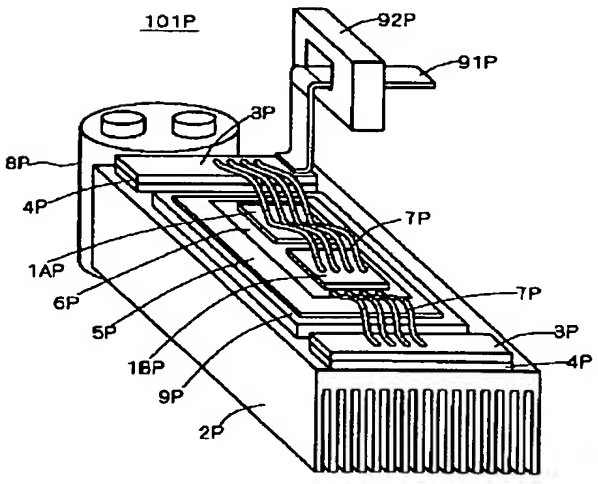

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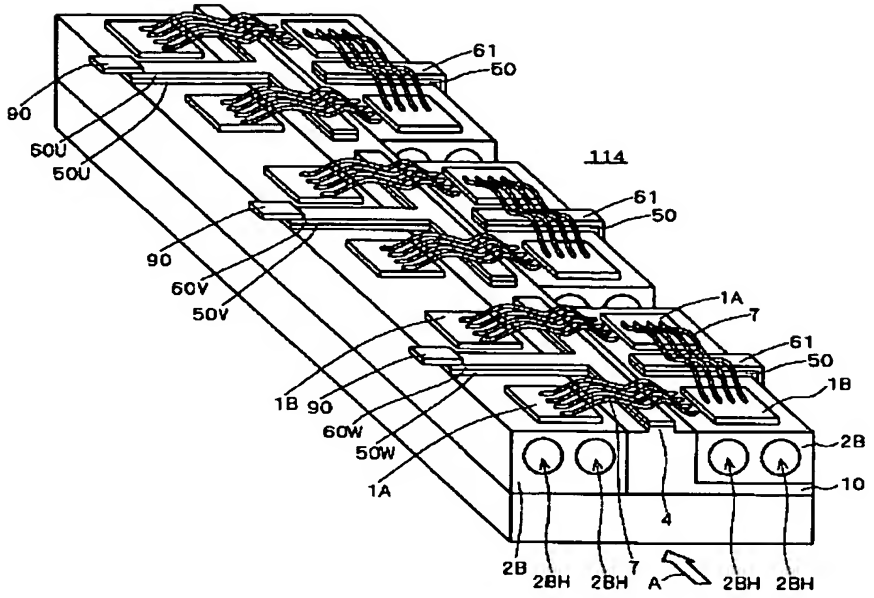
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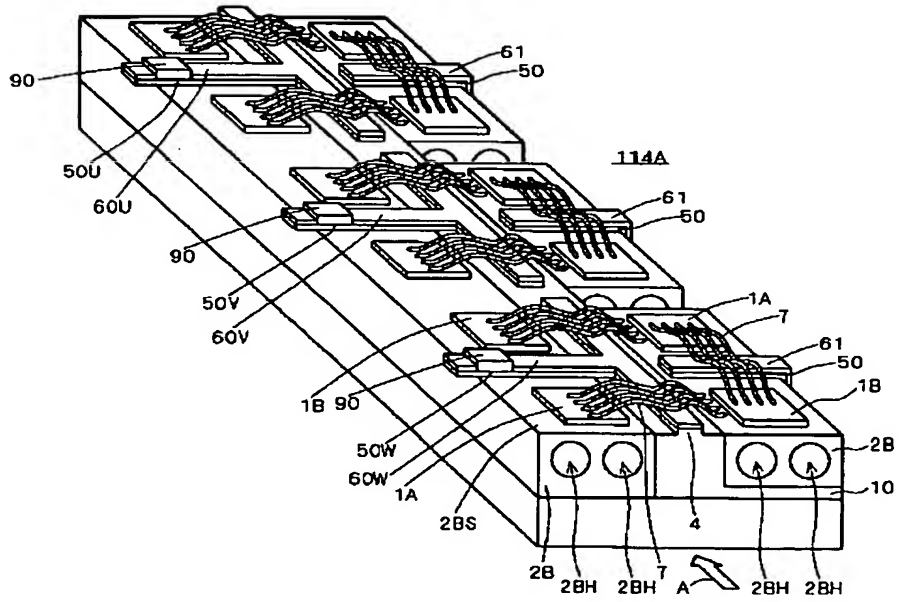
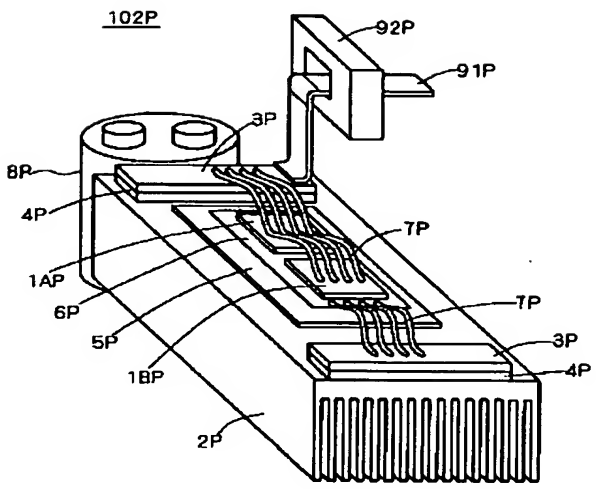
50U
114
61
50
90
60V
50V
1A
7
61
50
1B
1B
90
60W
50W
2B
1A
10
4
2B
2BH
2BH
7
A
2BH
2BH

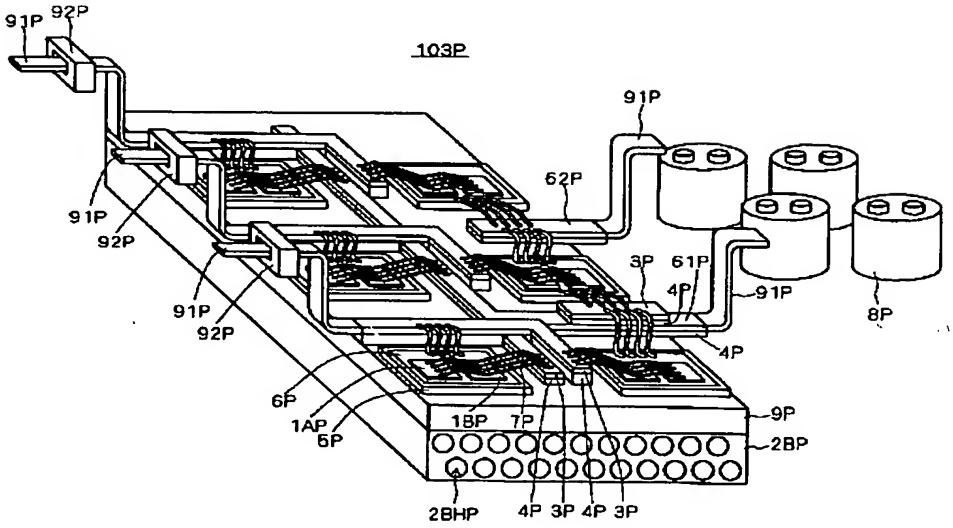
【図３３】


61
50
90
50U
60U
114A
61
50
90
50V
60V
1A
7
61
50
1B
1B
90
50W
60W
2B
1A
10
2BS
4
2B
2BH
2BH
7
A
2BH
2BH

【図３５】



【図３６】



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